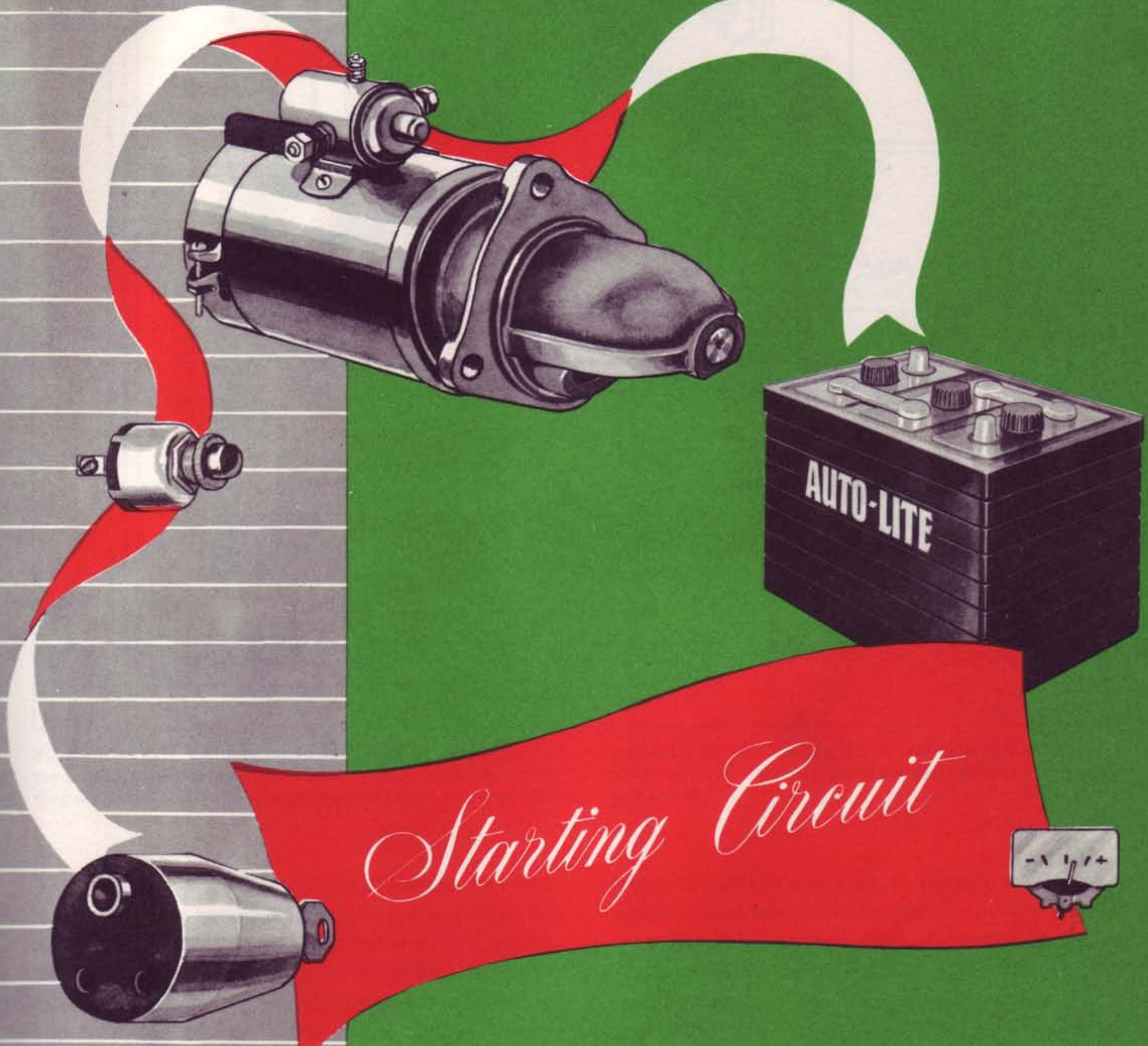
Starting Circuit



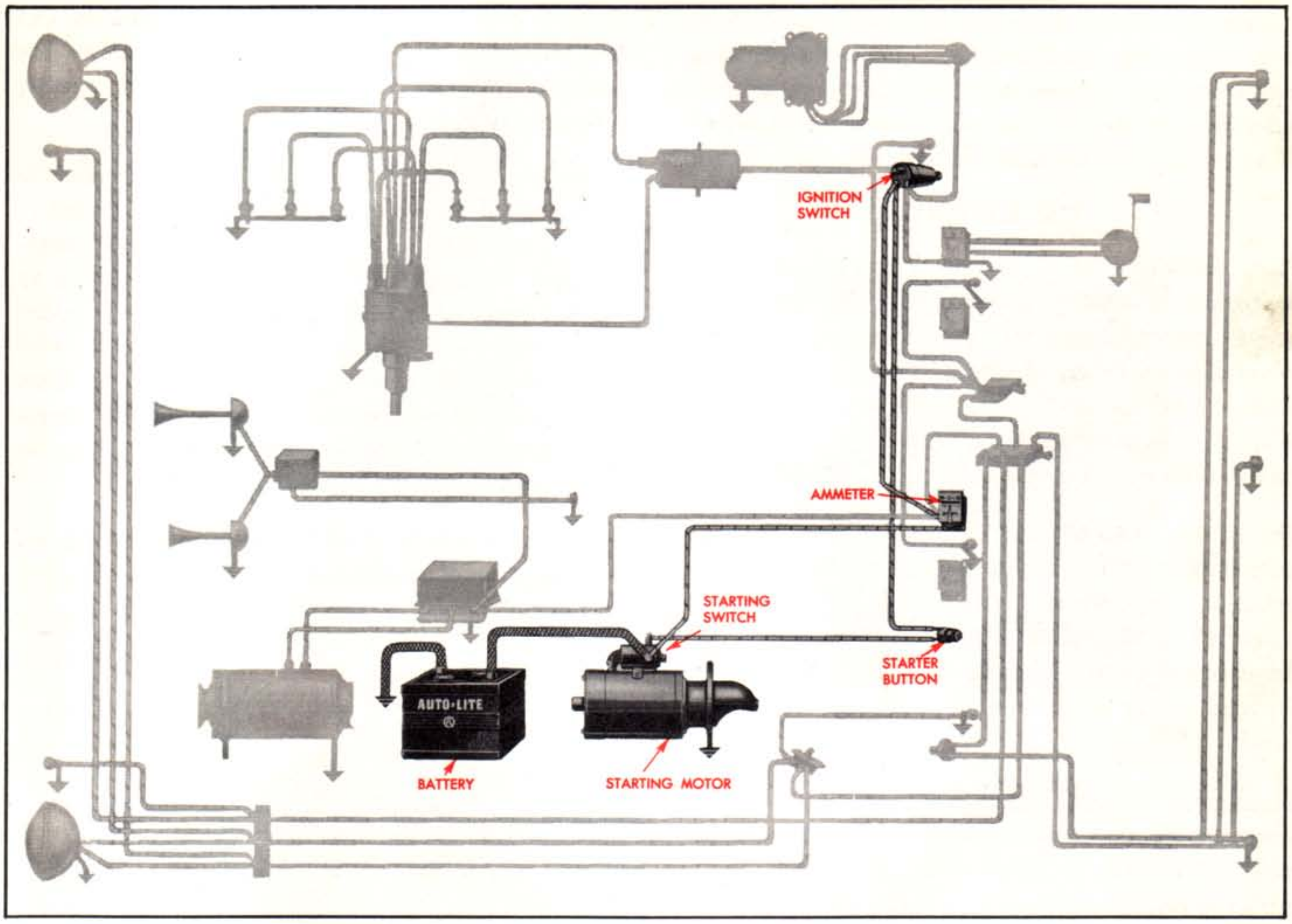


FIGURE 2—THE STARTING CIRCUIT—This illustration of the starting circuit is taken directly from the complete car wiring diagram shown in figure 1 and shows only those units and wires that enter into the starting circuit. For variations of the starting circuit showing different types of starting switches refer to figures 8, 9 and 10.

CHAPTER 2. THE STARTING CIRCUIT

The starting circuit (Figure 2) provides power for cranking the internal combustion engine and performs this action through the use of the starting motor, starting switch and battery. The motor receives electrical power from the battery and converts it into mechanical power which is transmitted to the engine through a drive pinion gear and the flywheel ring gear. A starting switch controls the operation by making and breaking the circuit between the battery and motor. The motor pinion gear is disengaged when at rest and is shifted into mesh with the ring gear either by mechanical action through a shift fork or by the rotating action of the starting motor armature. When the engine starts, the pinion is driven by the flywheel and, on some types, screw action causes the pinion to back out of the mesh with the flywheel. On other types a clutch releases and allows the pinion to turn faster than the armature shaft. When the control switch is opened, the motor armature stops revolving and the pinion returns to the "at rest" position. If there were no clutch or release action incorporated in the motor drive pinion, the high ratio between the flywheel gear and the pinion gear would cause the starting motor armature to turn at excessively high speeds, resulting in the armature windings being thrown out of the core by centrifugal force.

The battery, starting motor, starting switch and the wiring are all designed for the high currents needed to produce sufficient cranking power. Extreme care must be taken in the selection of the correct cable size and in making all connections, as even a small amount of resistance can cause a material reduction in the cranking power. Starting switches must have large contact surfaces and positive action to reduce resistance and minimize burning of the contacts when the switch is released.

THE BATTERY

The primary function of the battery is to provide power to operate the starting motor. It must also supply the ignition current during the starting period and to accomplish this even under adverse conditions of temperature or other factors. The battery also supplies power to operate the parking lamps or other equipment which may be used when the engine is not operating.

The battery does not actually store electricity as is commonly believed but it does convert electricity into chemical energy which is stored until the battery is connected to an external circuit at which time the chemical energy is transformed back into electrical energy and current flows through the circuit.

The storage battery (Figure 3) is a lead-acid, electro-chemical device assembled in a one-piece molded box or container made of hard rubber or bituminous composition. It is divided into compartments or cells. When assembled with the elements and acid, each fully charged cell on open circuit, has a voltage of slightly over two volts. Three cells are used for a six volt battery and six cells for a twelve volt unit. Hard rubber cell covers are sealed in over the top of the cells with a hot asphalt composition.

There are four essential chemicals present: lead peroxide in the positive plates; lead in spongy form in the negative plates; sulphuric acid and water in the electrolyte (the liquid portion).

The positive plate (Figure 4) is a lead grid-like structure filled with lead peroxide active material, chocolate brown in color. The negative plate (Figure 5) is a lead grid, filled with sponge lead, of a slate grey color. There are seven positive and eight negative plates in each cell of a six volt, fifteen plate battery. The positive plates in a cell are grouped in spaced relation and lead welded into a unit. The negative plates are assembled likewise. The two groups are nested together with positive and negative plates interleaved.

Separators consisting of porous rubber or chemically treated wood with raised ribs such as illustrated in figure 6, are inserted between each positive and negative plate to keep them from touching and causing an internal short circuit. Glass fibre mats or perforated rubber sheets are frequently used in conjunction with separators to retain the active material in the plates and protect the separators from oxidation. The complete assembly of plates and separators in a cell is called an element.

The element is covered with the electrolyte which is a water solution of sulphuric acid having a specific grav-

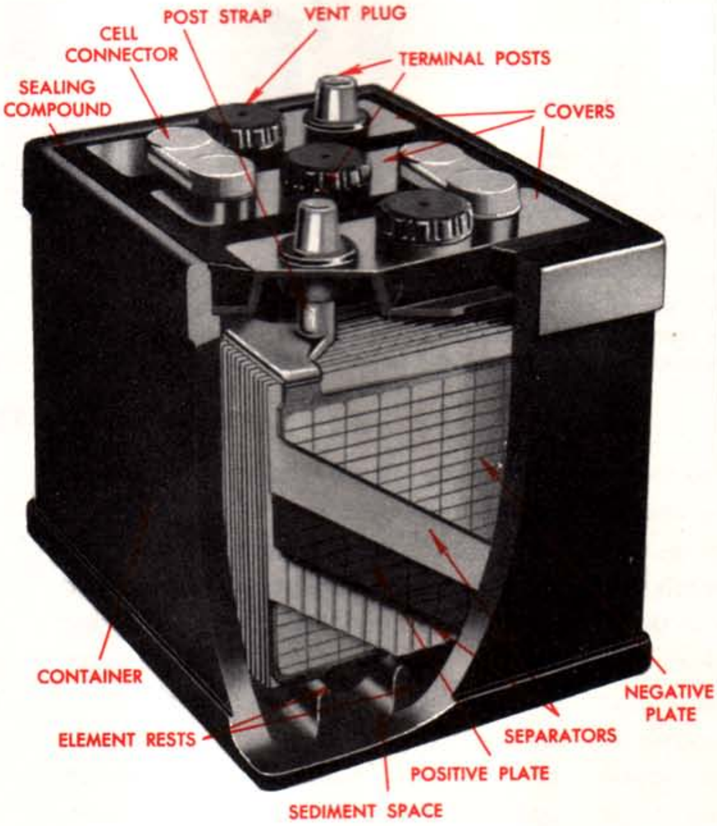


FIGURE 3—CUTAWAY VIEW OF A STORAGE BATTERY. **This cutaway view of a battery shows the various components and how they are assembled. Refer to figures 4, 5 and 6 for illustrations of the plates and separators used in the assembly.**

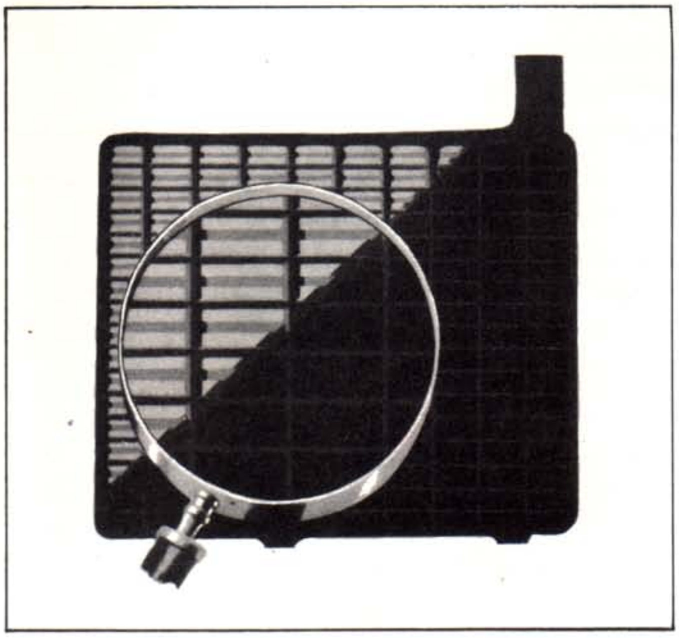


FIGURE 4—POSITIVE BATTERY PLATE. This is a view of the positive plate and shows the lead grid framework and the lead peroxide active material.

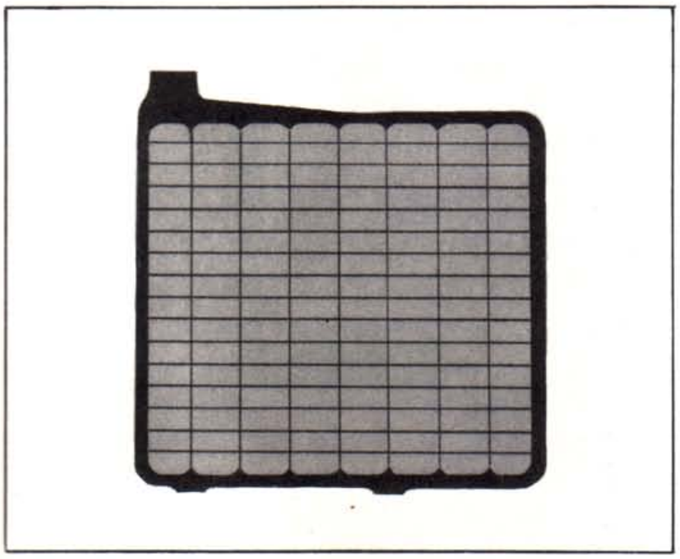


FIGURE 5—NEGATIVE BATTERY PLATE. The negative plate has a lead grid framework similar to the positive plate but the active material is sponge lead which is gray in color.

ity of 1.285 at 80° F. (The Auto-Lite Sta-Ful, because of special internal construction, has a greater volume of electrolyte with specific gravity of only 1.260 at 80° F. when fully charged. These batteries need addition of water to replace evaporation loss only one-third as often in normal service.)

Note: The Specific gravity of the storage battery varies with the temperature and also the state of charge. In order to obtain an accurate indication of the condition of the battery, the specific gravity should always be corrected to the standard temperature (80° F. or 26° C.). The method of taking readings and making the corrections is explained more fully in the battery maintenance on page 50.

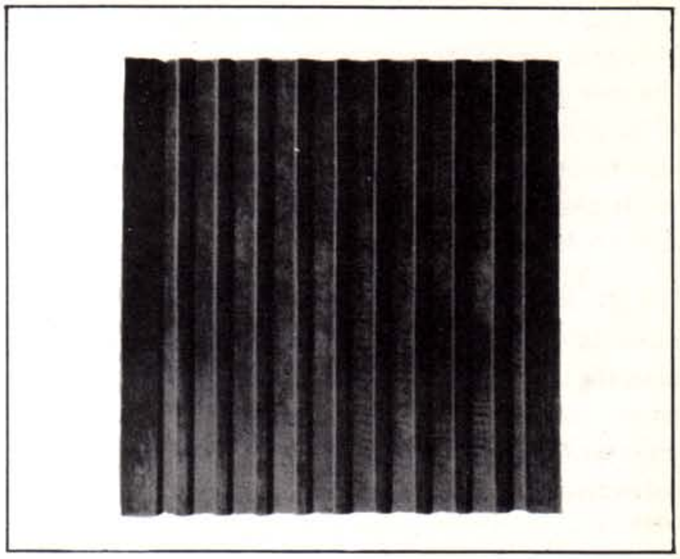


FIGURE 6—SEPARATOR. This is a wood separator and is made of thin porous wood. The ribs are raised slightly to allow the electrolyte to reach all parts of the plates and saturate the porous lead peroxide in the positive plates and sponge lead in the negative plates. Sometimes porous rubber is used for separator material rather than the wood illustrated.

When the circuit is closed the sulphate of the electrolyte starts combining with the active materials of both positive and negative plates, changing these materials to lead sulphate and the battery starts discharging. The loss of the sulphate from the electrolyte reduces its weight making it possible to check the battery's state of charge by measuring the specific gravity with a battery hydrometer. (Refer to Chapter 3 for the method of making specific gravity readings.) At the same time the oxygen displaced from the positive plates enters the electrolyte, combines with the hydrogen and results in water. A completely discharged battery, therefore, has positive and negative plates that are alike with lead sulphate active materials and water for electrolyte.

The characteristic of the battery which makes it so adaptable for its purpose is its reversibility. When discharged, it is reactivated by passing an electrical current through it in the opposite direction. Doing so reverses the foregoing chemical action. See figure 7.

The lead sulphate is changed to lead peroxide in the positive plates and sponge lead in the negative plates. The sulphate leaves the plates, combines with the water, and changes the electrolyte to sulphuric acid. Water must be added to replace that which is decomposed into hydrogen and oxygen gases during charge.

The number of plates, their size and thickness, and the amount of electrolyte determines the battery's capacity. The open circuit voltage of a cell, regardless of the size of the cell remains the same. Three cell, 13 plate or 21 plate batteries have the same open circuit voltage but the 21 plate battery will have greater capacity and a higher voltage on discharge.

The efficiency of a fully charged battery is in direct relation to atmospheric temperatures which raise and lower the temperature of the electrolyte. A fully charged battery with an electrolyte temperature of 80° F. is considered to be capable of 100% performance. An electrolyte temperature of 32° F. renders the battery 65% effective in cranking power and an electrolyte temperature of 0° F. leaves the battery only 40% effective.

BATTERY MAINTENANCE

Any adverse development in the starting circuit has a direct bearing on the operation, condition, and life of the battery. Check the starting motor and wiring as described in other parts of this chapter and refer to Chapter 3 on the generating circuit for battery maintenance and replacement.

All of the electrical circuits on the engine are connected to the battery and a defect in the wiring or electrical equipment may have a detrimental effect on the battery. If the battery is being undercharged or overcharged consult Chapter 9 for a guide in locating the cause of the trouble and refer to the battery maintenance section in Chapter 3.

THE STARTING CIRCUIT CABLES

The starting cables connect the various units in the starting circuit. The battery ground strap, battery to switch and switch to motor cables form the load circuit (see figures 8, 9, and 10), while the solenoid to starter button wire and the wire from the button to the ammeter or ground, form the control circuit. The windings of some solenoid switches are grounded in the switch and receive power from the battery through the starter button (see figure 9). Others have the solenoid windings connected to the switch battery terminal and are grounded by the starter button as shown in figure 10.

Occasionally both ends of the winding are brought out to the control terminals. This type is used on two-wire

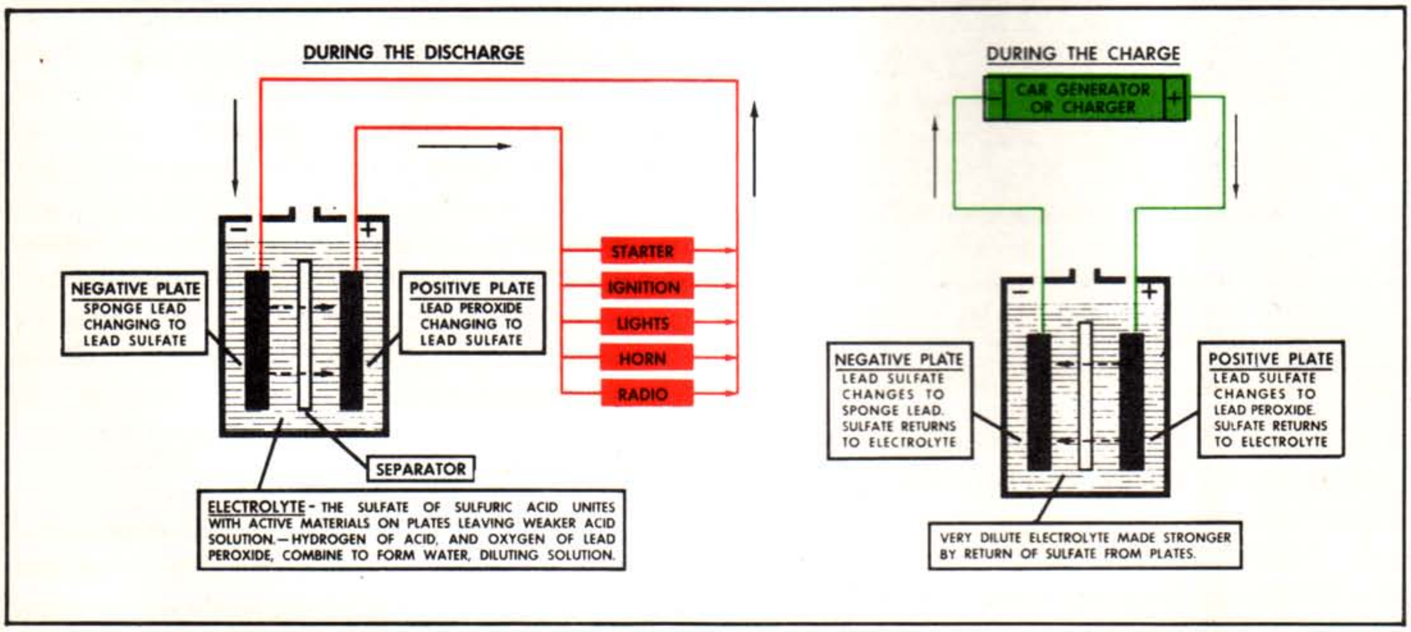

DURING THE DISCHARGE
−
+
NEGATIVE PLATE
SPONGE LEAD CHANGING TO LEAD SULFATE
POSITIVE PLATE
LEAD PEROXIDE CHANGING TO LEAD SULFATE
STARTER
IGNITION
LIGHTS
HORN
RADIO
SEPARATOR
ELECTROLYTE - THE SULFATE OF SULFURIC ACID UNITES WITH ACTIVE MATERIALS ON PLATES LEAVING WEAKER ACID SOLUTION.—HYDROGEN OF ACID, AND OXYGEN OF LEAD PEROXIDE, COMBINE TO FORM WATER, DILUTING SOLUTION.
DURING THE CHARGE
CAR GENERATOR OR CHARGER
−
+
NEGATIVE PLATE
LEAD SULFATE CHANGES TO SPONGE LEAD. SULFATE RETURNS TO ELECTROLYTE
POSITIVE PLATE
LEAD SULFATE CHANGES TO LEAD PEROXIDE. SULFATE RETURNS TO ELECTROLYTE
VERY DILUTE ELECTROLYTE MADE STRONGER BY RETURN OF SULFATE FROM PLATES.

FIGURE 7—CHEMICAL ACTION DIAGRAM. The left hand view above shows the chemical action which takes place in a battery during discharge while the right hand view shows the reverse action which takes place during charge.

systems or where some additional starter control such as a relay are used. With a relay in the circuit the starting switch will not operate until the relay has been closed by an additional operation such as turning on the ignition or adjusting some other engine control.

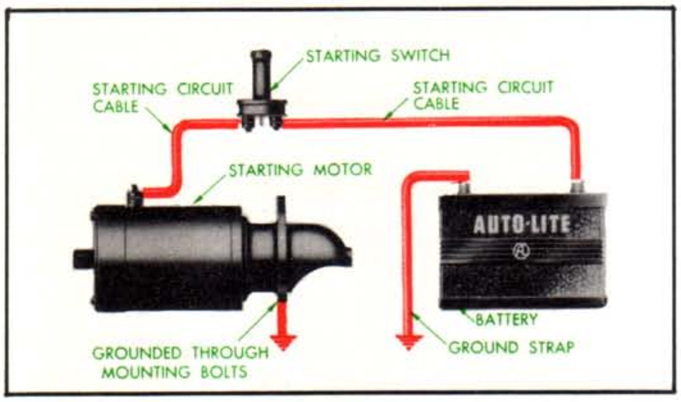


FIGURE 8—STARTING CIRCUIT WITH MANUAL SWITCH. This illustration shows the same basic circuit as figure 2 however a manually operated switch is used and there is no need for the switch control button and wiring. Sometimes the manual switch is mounted separate from the motor and is actuated by foot or hand. Other motors may have the switch mounted on the motor and be operated by wire or linkage.

The battery ground strap, and the cables between the battery, starting switch and motor must have sufficient capacity to carry the large starting current with small loss due to resistance. Size 0 to 000 cables are usually used but larger cables should be used if they are more than a few feet long. The cable size is also dependent upon the size of the equipment involved as the larger starting motors draw more current and require more cable capacity. If these load cables are too small there is a loss of starting motor efficiency due to the reduced voltage applied to the motor terminal. To check the size of the cables inspect the wiring and check for voltage loss as described in the starting cable maintenance.

STARTING CIRCUIT MAINTENANCE

Every 2 weeks to 1 month, usually when the battery is checked and water added, the cable terminals should be inspected for corrosion and looseness. Wash corroded terminals with a solution of baking soda and water, then coat the terminals with vaseline. If the terminals are loose on the battery stud they should be tightened.

Inspect to make sure the cables are not partially broken where they enter the terminals and replace the cable if any breaks are found. Inspect for damaged or chafed insulation on the battery to switch and switch to motor cables and replace the cable if the insulation is not in good condition. Make sure the terminals are not corroded and that all terminal nuts or screws are tight.

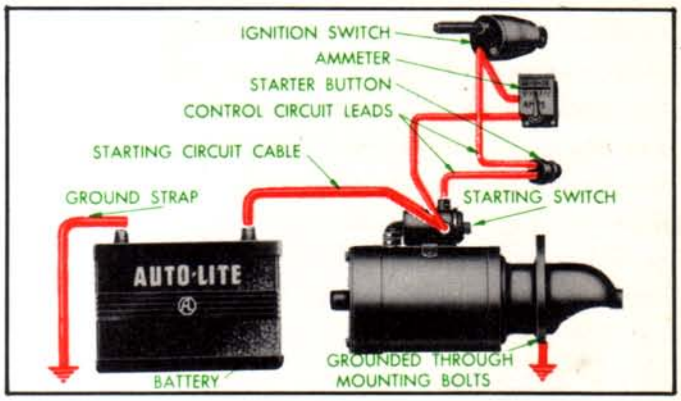


FIGURE 9—STARTING CIRCUIT WITH SOLENOID SWITCH. This is the same basic circuit as is shown in figure 2 shown in a form similar to figures 8 and 10 so that a comparison can be made between the various types. The internal connections of this switch are shown in figure 45.

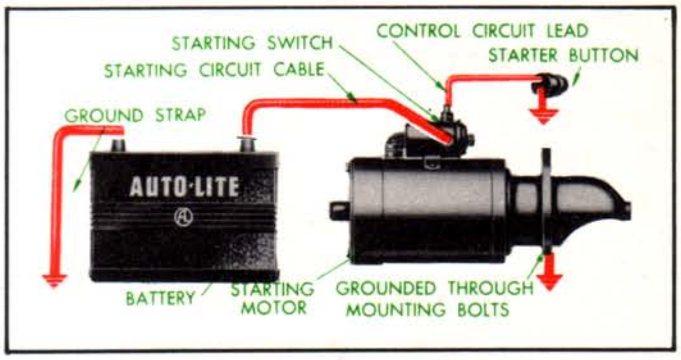


FIGURE 10—STARTING CIRCUIT WITH SOLENOID SWITCH. This circuit is similar to that shown in figures 2 and 9, however, the solenoid switch receives its power directly from the battery and its winding is grounded by the push button. The internal connections of this switch are shown in figure 46.

On solenoid switches the control circuit should be inspected for broken wires, loose connections or terminals and for damaged insulation.

If there is some indication that the starting motor is not producing enough power, the starting circuit should be given a voltage loss test to determine if the cables and switch are in good condition and have sufficient capacity. This test should also be made whenever the starting motor has been overhauled and reinstalled. Connect a low reading voltmeter to the battery terminal and to the starting motor terminal. Crank the engine in the normal manner and read the voltmeter.

This drop should be less than 0.30 volt per 100 amperes flowing in the circuit. The approximate current can be estimated from the specifications for the various types of starting motors. The cranking current will usually be slightly less than the stall torque current at ⅓ the rated voltage although this may vary depending upon the condition and temperature of the starting motor and engine. If the motor is cranking easily or if the battery is low, the current will be somewhat less; while if the starting motor is laboring, the current draw will be higher. If the voltage loss is more than 0.30 per 100 amperes check the loss from the battery to starting switch, starting switch to motor and across the starting switch.

Repeat above procedure on the ground circuit by connecting the voltmeter first to the battery ground terminal and the starting motor frame. If this voltage loss is more than .10 volt per 100 amperes check the voltage from the battery ground terminal to the engine block and from the engine block to the starting motor frame. The first reading will be an indication of the condition of the battery ground strap while the second reading will indicate whether the starting motor is properly grounded through its mounting bolts.

THE STARTING MOTOR

The starting motor illustrated in figures 11, 12, 13, 14, and 15 converts electrical energy from the battery into mechanical power and transmits the power to the engine. If consists of a frame and field, armature, commutator end head, drive end head or housing and a drive mechanism. The frame and field assembly has a steel frame which supports the components of the motor and also forms part of the magnetic path. Field windings, consisting of coils of copper strips or wires, produce a magnetic field which is conducted through

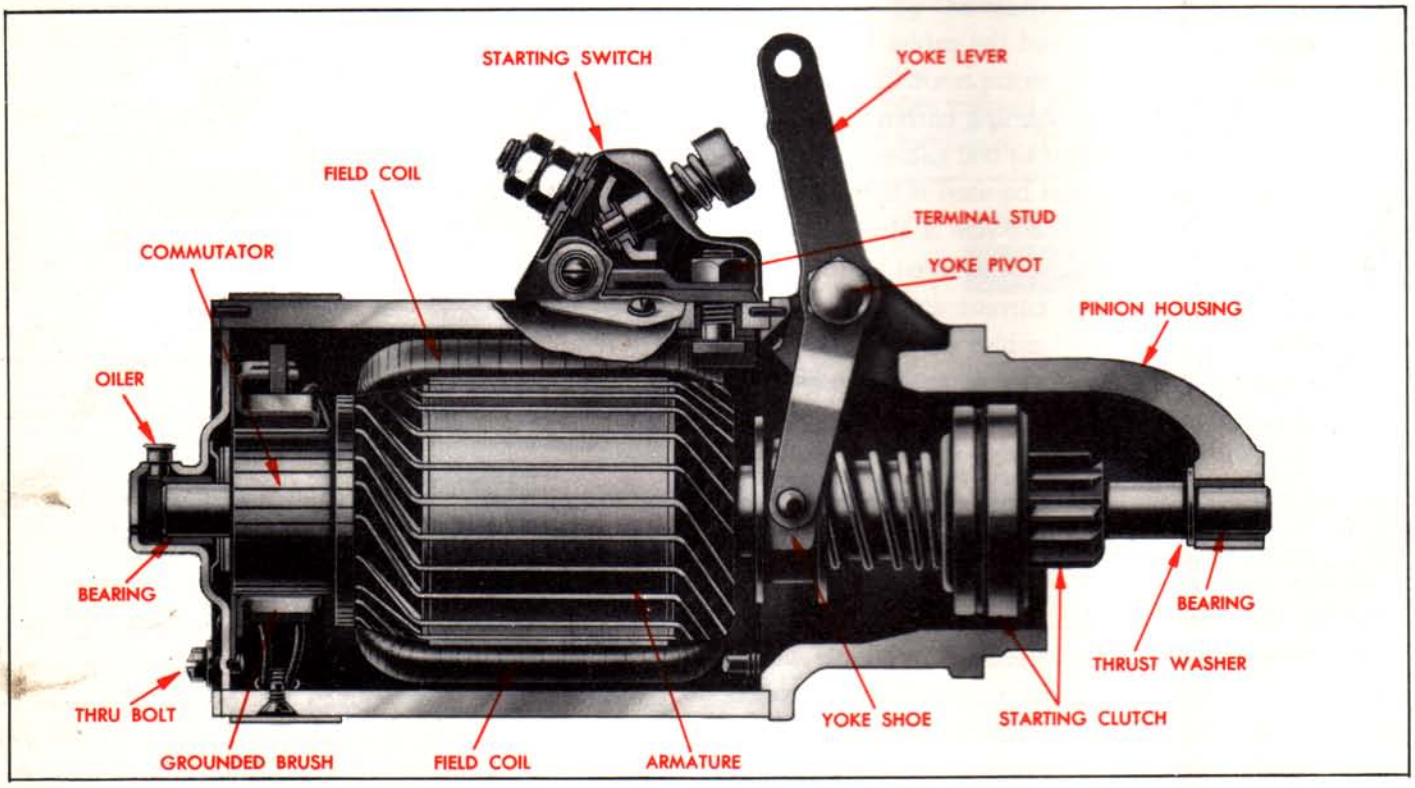


FIGURE 11—STARTING MOTOR WITH OVERRUNNING CLUTCH AND MANUAL SWITCH. This motor has a manually operated overrunning clutch which is shifted by pressing a pedal on the floor board. The pedal is linked to the yoke lever and shifts the clutch mechanism into mesh with the flywheel before the starting switch closes.

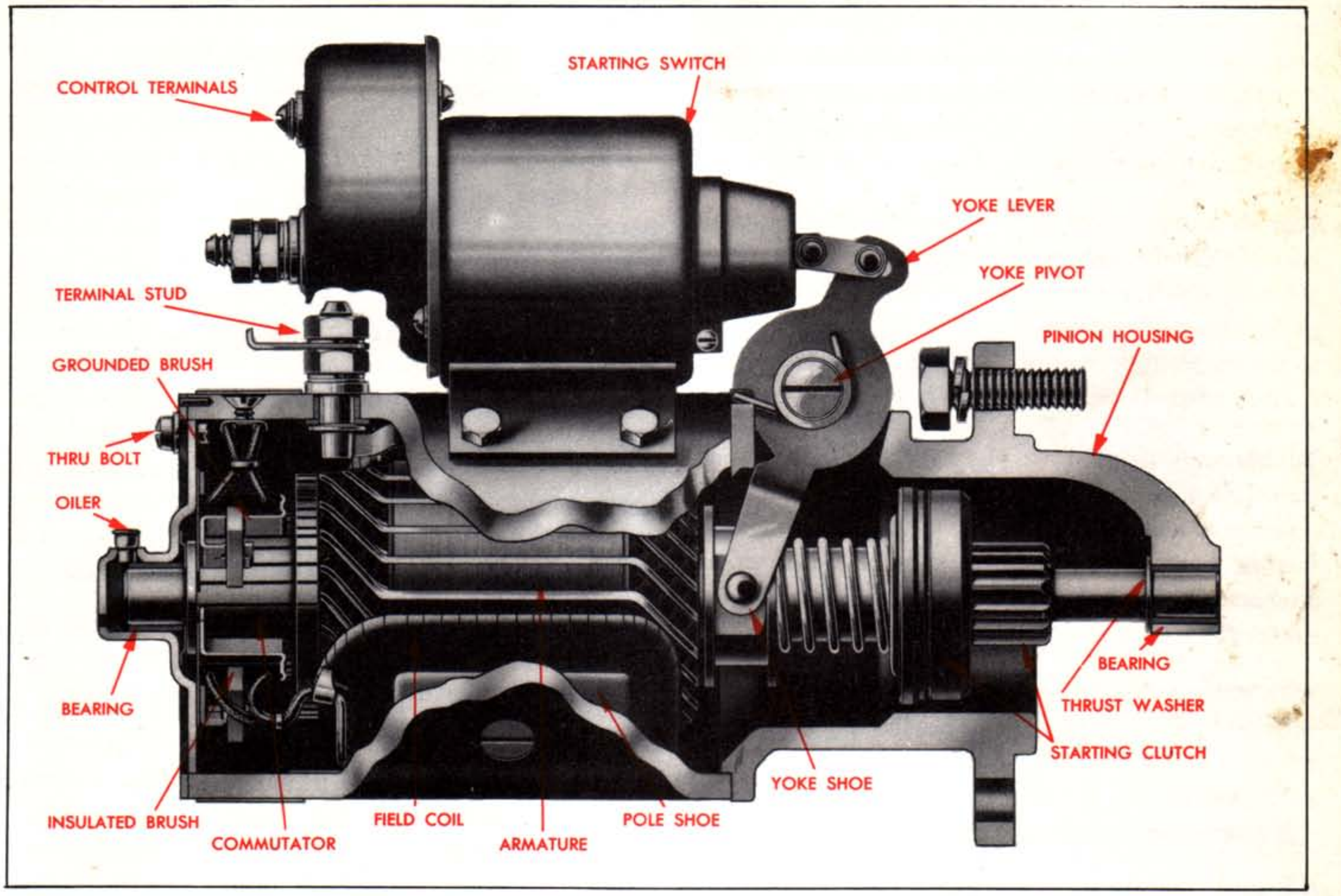


FIGURE 12—STARTING MOTOR WITH OVERRUNNING CLUTCH AND SOLENOID SWITCH. This motor is similar to that shown in figure 11 except that a solenoid switch is used and the yoke lever is shifted by solenoid action.

steel pole shoes to the armature. The armature core is also steel to complete the magnetic circuit. Copper conductors are installed lengthwise in slots around the armature core and are connected to a commutator consisting of a number of copper segments insulated from each other and from the armature shaft. The armature turns in bearings mounted at each end of the motor, and brushes in the commutator end head make electrical contact with the revolving commutator.

Starting motors vary as to size, number of poles or brushes, method of mounting, type or connections of the internal wiring and in the method of transmitting the power to the flywheel. Four poles and brushes are commonly used for 6 and 12 volt equipment, while 24 volt motors and other heavy duty equipment may have 4 poles with 8 brushes or some other combination. Usually the motor is mounted by a flange on the pinion housing or drive end head, though sleeve or base mountings are sometimes used. Motors designed for inboard meshing or which have the drive mechanism entirely within the flywheel housing, use a head to close the drive end of the frame and support the armature shaft. For outboard type mountings a pinion housing closes the drive end of the frame and field and provides support for the armature shaft at its extreme end. In some motors a bearing is installed near the middle of the armature to provide additional support.

Most starting motors are of the series type; that is, the field coils and armature windings are connected in series so that all of the current flows through both the field and armature. See figures 16 and 17. The field coils may be either all in series (Figure 16) or be connected in a series parallel combination which divides the current into two equal parts and conducts each half to an insulated brush (Figure 17). With this latter type, an equalizer connection is sometimes used to connect the two insulated brushes and compensate for differences in current in the field coils due to slight variations in the winding and brush contact conditions.

Gear reduction motors, such as illustrated in figure 15 have the drive clutch mechanism mounted on a separate shaft which is driven by the armature through two gears. This results in an increase in the torque applied to the engine flywheel but this gain is at a cost of reduction in speed and a slight loss in efficiency.

To transmit the power to the flywheel of the engine Auto-Lite starting motors use either an overrunning clutch or a Bendix drive. The overrunning clutch type starting motor drive (Figure 18) may be shifted either mechanically through the starter pedal (Figure 11) or electrically by a specially designed Solenoid (Figure 12).

With either method, the clutch pinion remains in mesh with the flywheel ring gear as long as the starter pedal or button is held down. With a Bendix Drive (Figures 19, 20, 21, and 22) the pinion is mounted on a screw thread and disengages as soon as the engine starts.

A typical overrunning clutch is illustrated in figure 18. The clutch has internal splines to match the splines on the armature shaft. When the yoke lever is shifted, either mechanically or by solenoid action, the complete drive is moved along the armature shaft until the pinion gear meshes with the flywheel ring gear. Just before the pinion is completely meshed, the starting switch is closed by the same pedal or solenoid action and the starting motor cranks the engine. If the pinion teeth do not mesh with the flywheel teeth, the shift collar slides along the clutch shaft and compresses the spring. This allows the yoke to shift far enough to close the switch contacts. As soon as the starting motor armature starts to turn, the clutch spring completes the meshing action. When the engine starts, the flywheel drives the pinion faster than the armature shaft. This unlocks the rollers in the clutch mechanism and the pinion spins without turning the armature shaft at excessive speeds.

When the starter pedal or button is released, spring action returns the yoke to the "at rest" position and moves the drive clutch out of mesh with the flywheel gear.

The Bendix Drive has been built in a number of different forms but all operate by a combination of screw action and inertia. The pinion is mounted on a threaded sleeve which is driven by the armature either by splines within the Bendix sleeve or by a spring which has one

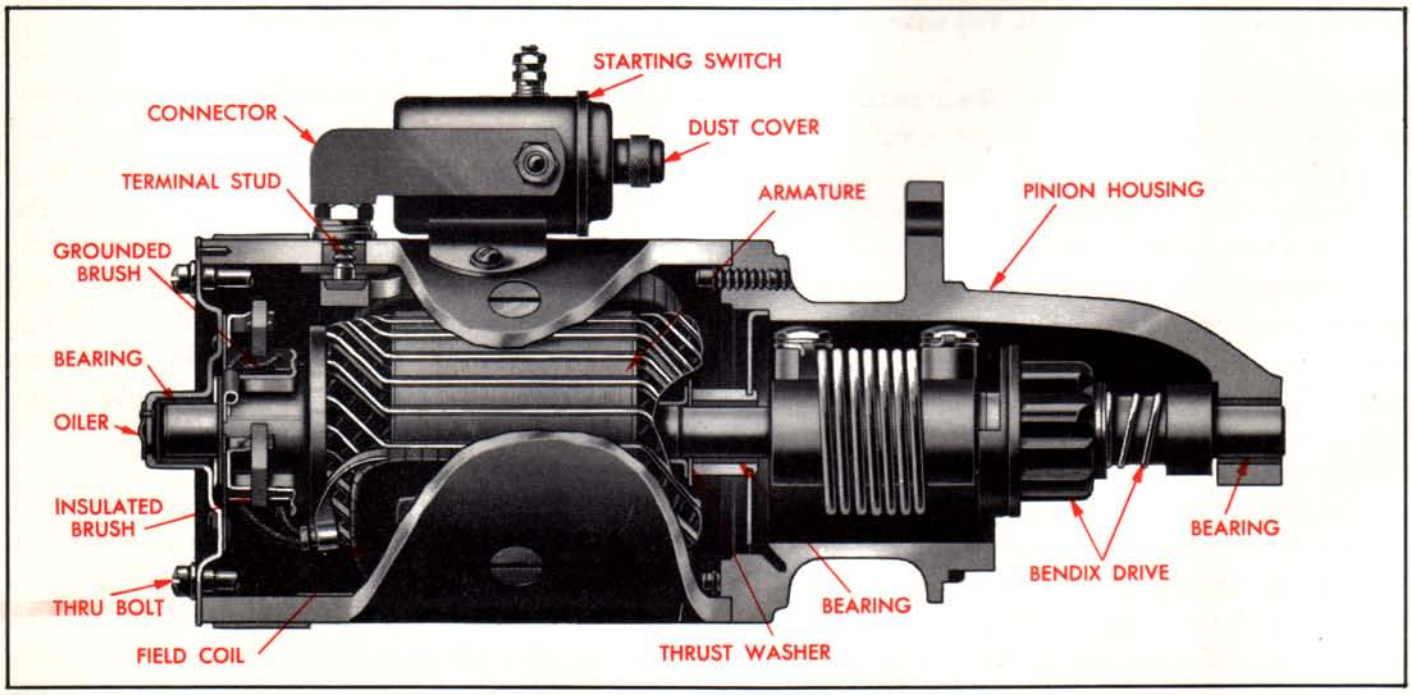


FIGURE 13—STARTING MOTOR WITH BENDIX DRIVE. This motor has a standard type Bendix drive which is shifted by screw action and drives the flywheel through the heavy drive spring.

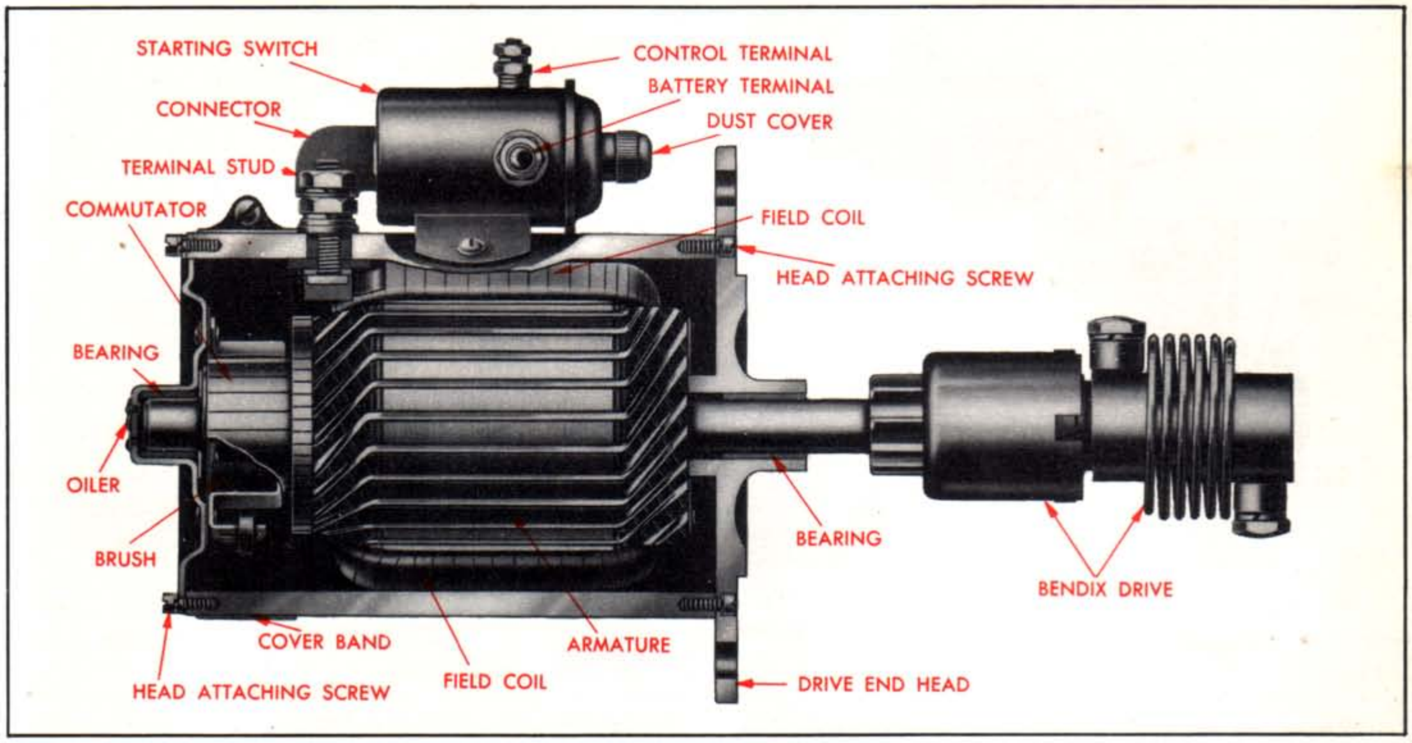


FIGURE 14—STARTING MOTOR WITH BENDIX DRIVE. This motor has a barrel type Bendix drive which is mounted for inboard meshing. No pinion housing is used as the drive mechanism mounts inside of the flywheel housing.

end connected to the armature shaft and the other connected to the Bendix shaft. The most common Bendix types are illustrated in figures 19 and 20, while figure 21 shows a drive that is usually used on light applications and figure 22 shows a clutch type Bendix for use on heavy duty motors.

When the starting motor circuit is closed the armature revolves, turning the Bendix sleeve within the pinion. The screw action forces the gear forward into mesh with the flywheel gear. The sudden shock of the meshing is absorbed by the Bendix spring.

When the engine starts, the pinion is driven faster than the shaft and is threaded back along the screw shaft out of mesh with the flywheel.

Clutch type Bendix drives operate on the same principle as just described but they are designed for heavy duty applications and incorporate a friction clutch which slips when overloads occur.

STARTING MOTOR MAINTENANCE

Due to the location and construction of starting motors no maintenance operations are possible, except for periodic lubrication, cleaning of the outside of the motor and checking for looseness of mounting. Because of this, starting motors are designed to require no service except for lubrication, and, in many instances, sufficient oil is incorporated in the construction of the motor to eliminate the necessity of periodic lubrication.

The starting motor will normally perform without attention throughout the life of the engine; however, dirt, dust, water, and frequent starting cause more rapid wear and deterioration and may make an overhaul necessary. Also should trouble develop in the starting motor, the complete overhaul should be performed as the additional trouble or expense involved is small compared to many partial jobs such as replacing brushes or cleaning the drive mechanism.

Do not remove the motor for an overhaul unless it is definitely known that it requires attention. Check the battery, cables and starting switch according to other parts of this chapter. If necessary, substitute a battery known to be fully charged and in good condition then operate the motor by disconnecting the battery cable from the starting switch and holding the cable terminal firmly against the starting motor terminal. On some installations it may be necessary to remove the starting switch to expose the motor terminal. Motors with Bendix drives should crank the engine at a normal

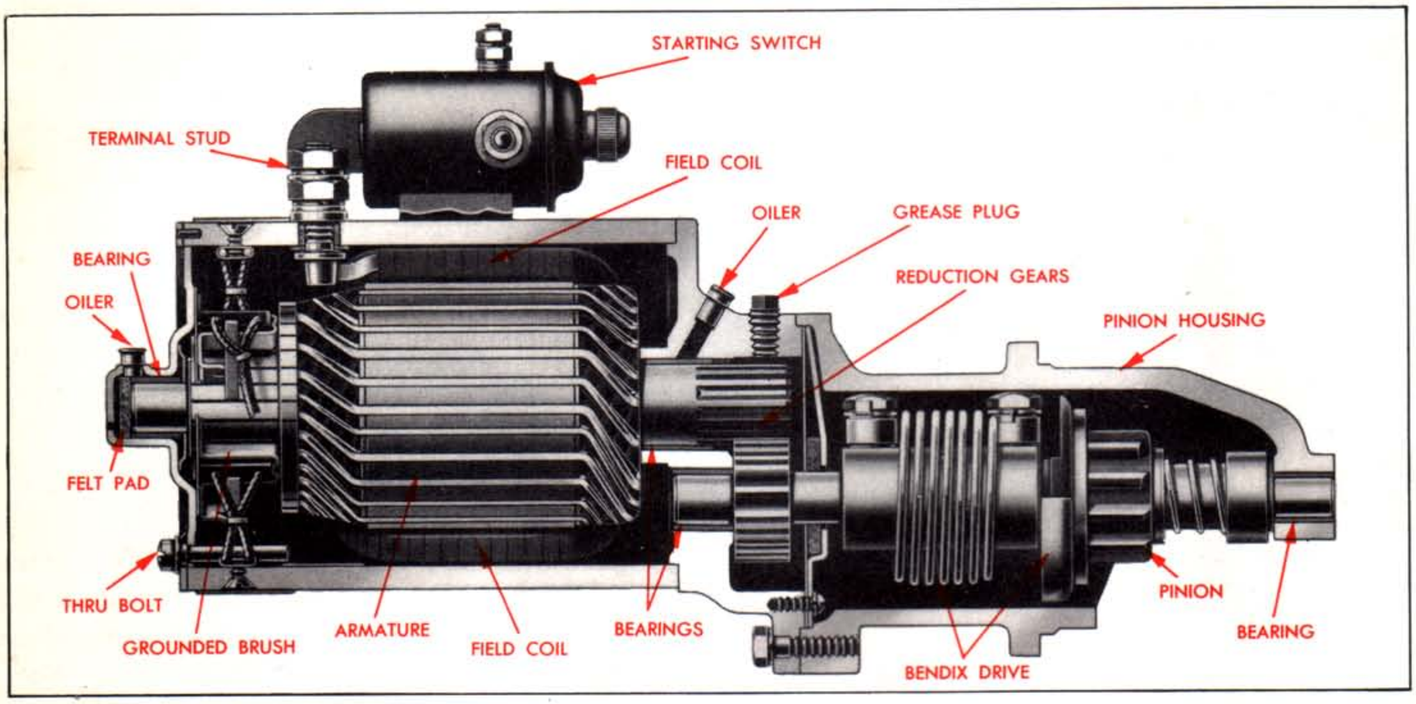


FIGURE 15—GEAR REDUCTION STARTING MOTOR. The gear reduction used in this motor increases the torque applied through the pinion. The other features of this motor are similar to that shown in figure 13.

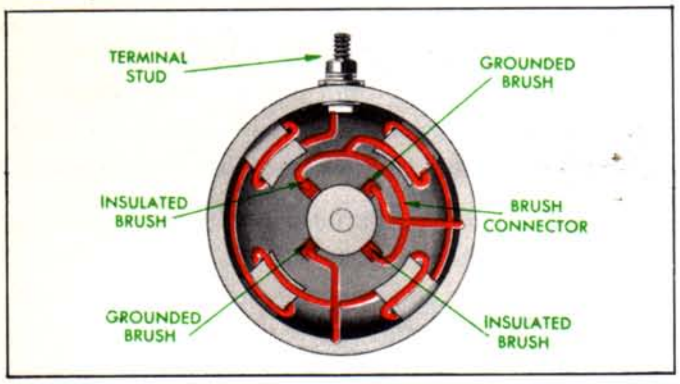


FIGURE 16—STARTING MOTOR INTERNAL CIRCUIT. This diagram shows all of the field coils connected in series. Many 12 and 24 volt motors use this hookup, although it may also be used for 6 volt units.

speed while overrunning clutch motors should spin at a high rate without cranking the engine. If the motor acts as described and if the drive mechanism is engaging and disengaging each time the starting motor is operated, do not remove the motor as the removal alone is a tedious and expensive operation that is quite often unnecessary.

The above recommendations apply only to the starting motor itself and not to the balance of the starting circuit which should be more frequently inspected. The battery, starting switch and starting cables should be checked as described in other parts of this chapter according to the periods recommended for each.

In order to obtain maximum efficiency of the starting motor the starting circuit should be frequently inspected and cleaned and the motor checked for loose or cracked mounting. Where oilers are provided, 3 to 5 drops of S.A.E. No. 10 engine oil should be added at regular chassis lubrication periods.

REMOVAL FROM ENGINE

Disconnect the leads from the starting motor. When the switch is mounted on the motor, the battery lead

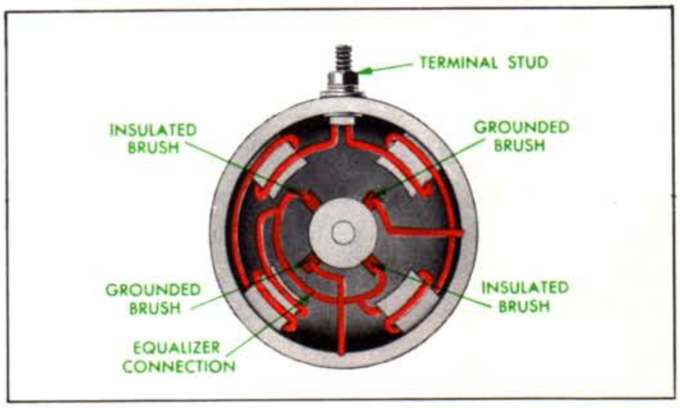


FIGURE 17—STARTING MOTOR INTERNAL CIRCUIT. This diagram shows a series-parallel hookup of the field coils and is most common on automotive starting motors. This is also called a series motor as the field and armature are in series and all current flows through both the armature and the field.

should be covered with friction tape or a short piece of hose to prevent shorting. Disconnect any pedal linkage directly connected to the starting motor or yoke, take out mounting bolts and lift motor from the engine.

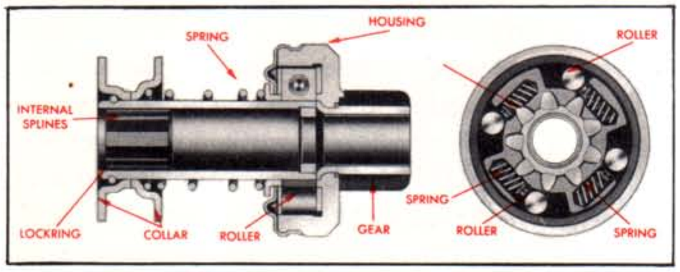


FIGURE 18—OVERRUNNING CLUTCH. This illustration shows the internal construction of an overrunning clutch. When the starting motor is driving the flywheel, the rollers move to the other end of their chamber and are wedged by the slight taper. This locks the pinion to the shaft and the torque is transmitted to the flywheel. When the engine drives the pinion gear, the rollers move to the above postion and the clutch releases.

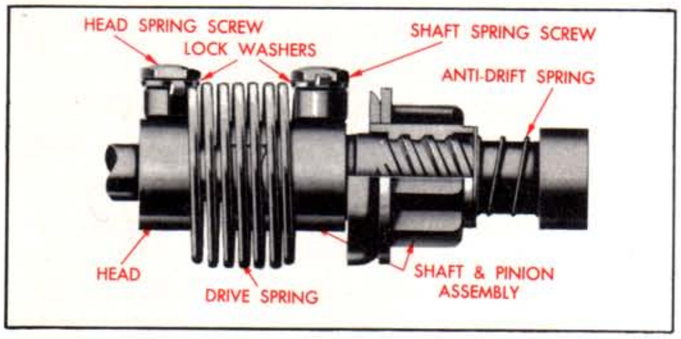


FIGURE 19—STANDARD TYPE BENDIX DRIVE. The standard type Bendix drive has the head keyed to the armature shaft and the torque is transmitted through the drive spring to the shaft and pinion assembly. The Bendix shaft is a slide fit on the armature shaft and allows the drive spring to absorb the shock of meshing. The pinion gear shifts on the screw threads through inertia while the anti-drift spring keeps the pinion in the "at rest" position except when the starting motor is in use.

PRELIMINARY TESTS

Remove the motor cover band. Place the motor on a "V" block or partially opened vise and connect for a "no load" test by connecting the motor terminal and frame to a battery of rated voltage. If the motor operates without shorts or laboring, disconnect the lead from the motor terminal and insert an ammeter and shunt with a capacity of at least 500 amperes. Connect a voltmeter from the motor terminal to the frame. See figure 23. Hold a tachometer against the drive end of the armature shaft and read the "no load" speed, voltage, and amperage. Inspect the brush action while operating at "no load." Compare the resulting figures with the test specifications at the end of this chapter. The results of this test will indicate what should be looked for when the motor is overhauled.

Low speed and low current. Look for high resistance which may be caused by a dirty commutator, worn or faulty brushes and brush leads, low brush spring tension or by poorly soldered field connections.

Low speed and high current. If accompanied by arcing of the brushes look for a faulty armature. If arcing is not excessive look for worn bearings and shaft and for insufficient end play.

Excessive arcing is caused by low brush spring tension, worn commutator or by a shorted or open armature. An open armature is readily detected because the arcing always occurs at a certain point and one spot on the commutator is burned.

Excessive brush movement may be caused by low brush spring tension or more commonly by an out-of-round or worn commutator.

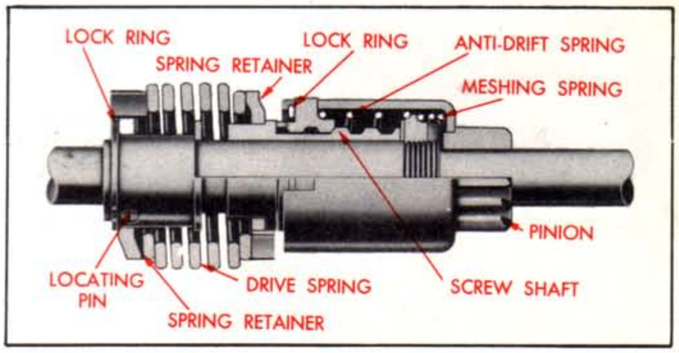


FIGURE 20—BARREL TYPE BENDIX DRIVE. The barrel type drive operates on the same principle as the standard type drive but has a different construction to improve its operation for some types of service and to enable complete disassembly and repair. The drive spring is locked to the armature and screw shafts by spring retainers rather than screws used in the standard type.

DISASSEMBLY *(See Figures 24 and 25)*

If brush holders are the box type, lift the spring with a hook and take the brushes out of the holders as shown in figure 26. On swinging type brushes disconnect the field coil lead from the insulated brush then slightly tighten the screw to keep brush in place. See figure 27.

Before disassembling commutator end heads that are fastened by a number of screws into the end of the frame, mark the frame and head so that they can be reassembled in their original position. This is not necessary on motors using through bolts to hold the heads and having a dowel pin to locate the commutator end head position.

Take out the through bolts or commutator end head and drive end housing attaching screws. If necessary, tap the commutator end head lightly with a rubber hammer and remove the head. Lift off the drive end head or pinion housing and the armature. On types with an intermediate bearing, the armature will remain in the pinion housing. On most motors this bearing assembly is a press fit in the pinion housing and can be forced out with an arbor press bearing on the drive end of the shaft. A few types of motors use screws or a lock ring to hold the intermediate bearing in place. These must be removed before pressing the armature out of the pinion housing. Gear reduction motors require the removal of the intermediate housing screws to complete their disassembly.

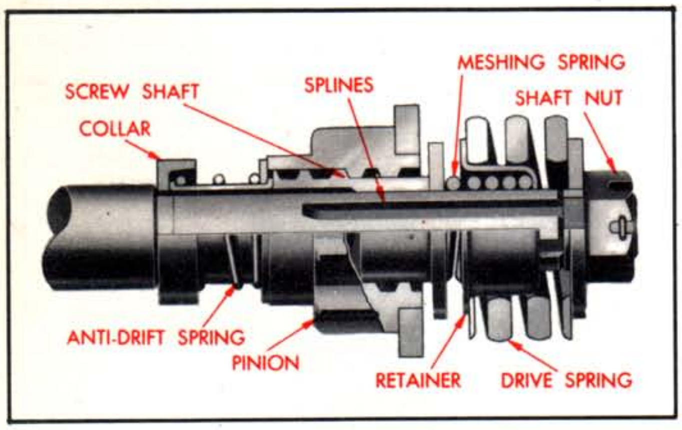


FIGURE 21—LIGHT DUTY BENDIX DRIVE. This drive also operates on the same principle as the standard type. Its construction permits complete disassembly but does not adapt itself for use on the larger motors.

ARMATURE INSPECTION

The armature should be visually inspected for mechanical defects such as a worn or bent shaft, worn commutator, scored core laminations and to see that all windings are properly in place in the core slots. Inspect for evidence of excessively high speeds which would throw the windings outward at the ends and may even cause them to leave the core slots.

Inspect to see that all windings are properly staked and soldered to the commutator. Resolder if necessary being careful not to short between coils or commutator bars.

With test probes such as illustrated in figure 28 test the armature for grounds by touching the shaft with one probe and the commutator with the other. Do not touch the test probes to the bearing or brush surfaces as an arc would burn the smooth finish. If the lamp lights the armature is grounded and should be replaced.

Clean the commutator with 00 or 000 sandpaper and remove all dirt from between the armature bars. Place the armature bearing surfaces on "V" blocks and place a dial indicator against the commutator as shown in figure 29. Turn the armature slowly and read the total runout. If over .003" runout, turn the commutator down with a lathe. Mount the armature by the shaft bearing surfaces in the lathe and take light cuts until the commutator is completely cleaned up. See figure 30. Remove all burrs with 00 or 000 sandpaper. This trueing up of the commutator should also be done if it is rough, burned or if the mica extends above the surface of the copper. Recheck the runout after turning the commutator.

Undercut the commutator mica. This cut should be exactly centered on the mica and a tool used that is .002 inch wider than the mica. The undercut should be clean and square and should remove all mica to a depth of $\frac{1}{32}$". See figure 31. If the burrs on the copper are not large they can be left on the commutator to help seat the brushes after assembly. However, be sure to remove the burrs with 00 sandpaper before completing the overhaul.

Place the armature on a growler and hold a thin steel strip on the core as illustrated in figure 32. Rotate the armature slowly and if the armature is shorted the steel strip will be come magnetized and vibrate. If a short is present inspect the commutator risers and bars

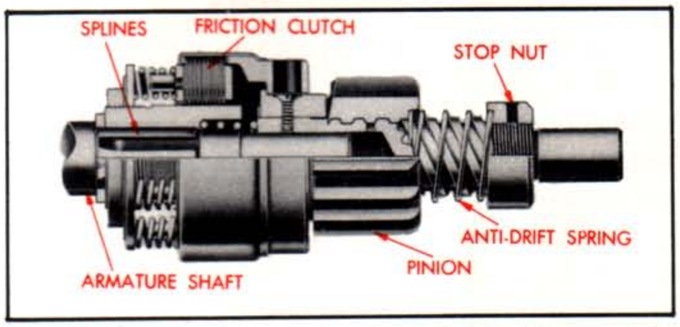


FIGURE 22—CLUTCH TYPE BENDIX DRIVE. This type drive incorporates a friction clutch which releases when overloads occur. It should not be disassembled or adjusted in the field as it is designed for heavy duty operation and requires special equipment for repairing or adjusting.

for copper chips or solder that may be shorting between the bars. If shorts cannot be found replace armature.

On corrosion resistant motors paint the core and windings with air drying varnish. (Schenectady Varnish Co. No. 170 or equivalent). Allow to dry thoroughly and clean all varnish from the commutator and shaft.

FRAME AND FIELD INSPECTION

Clean the frame and field with a cloth dampened in cleaning solvent but do not soak insulation or brushes. Inspect for faulty insulation and stripped threads. With test probes check for grounds by touching the terminal stud with one probe and an unpainted spot on the frame with the other probe. See figure 33. Be sure brushes or leads are not in contact with the frame.

If a ground is present remove the terminal stud nuts and if the stud is removable press it out of the frame, then recheck the field coils for grounds with the test probes. If the terminal stud is soldered to the field coils or if the field coils are grounded, remove the pole shoe screws and take the coils out of the frame. It is a good practice to mark one end of the frame and also the shoes before disassembly so that they can be installed in their original position and direction. Replace any faulty or damaged parts making sure all connections are tightly clinched then soldered to make a low resistance connection.

When installing coils and pole shoes, dip the pole shoe screws in boiled linseed oil before assembly. As the screws are tightened strike the frame one or two

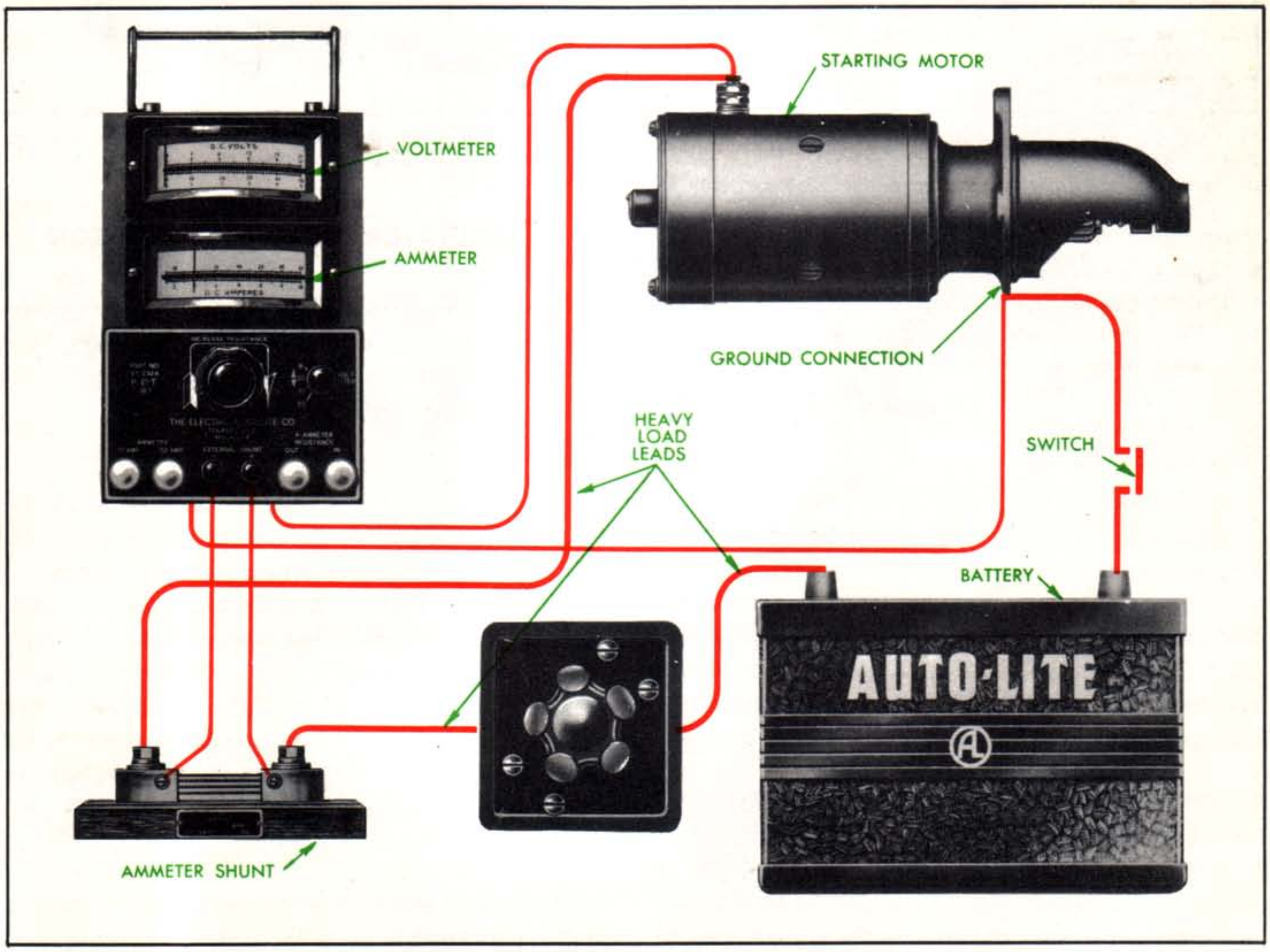


FIGURE 23—FOR STARTING MOTOR TEST WIRING DIAGRAM. This diagram shows the hookup for testing the starting motor and is used both for the "no load" test and stall torque test. The ammeter shunt should have a capacity well above the motor stall current to avoid damaging the meter.

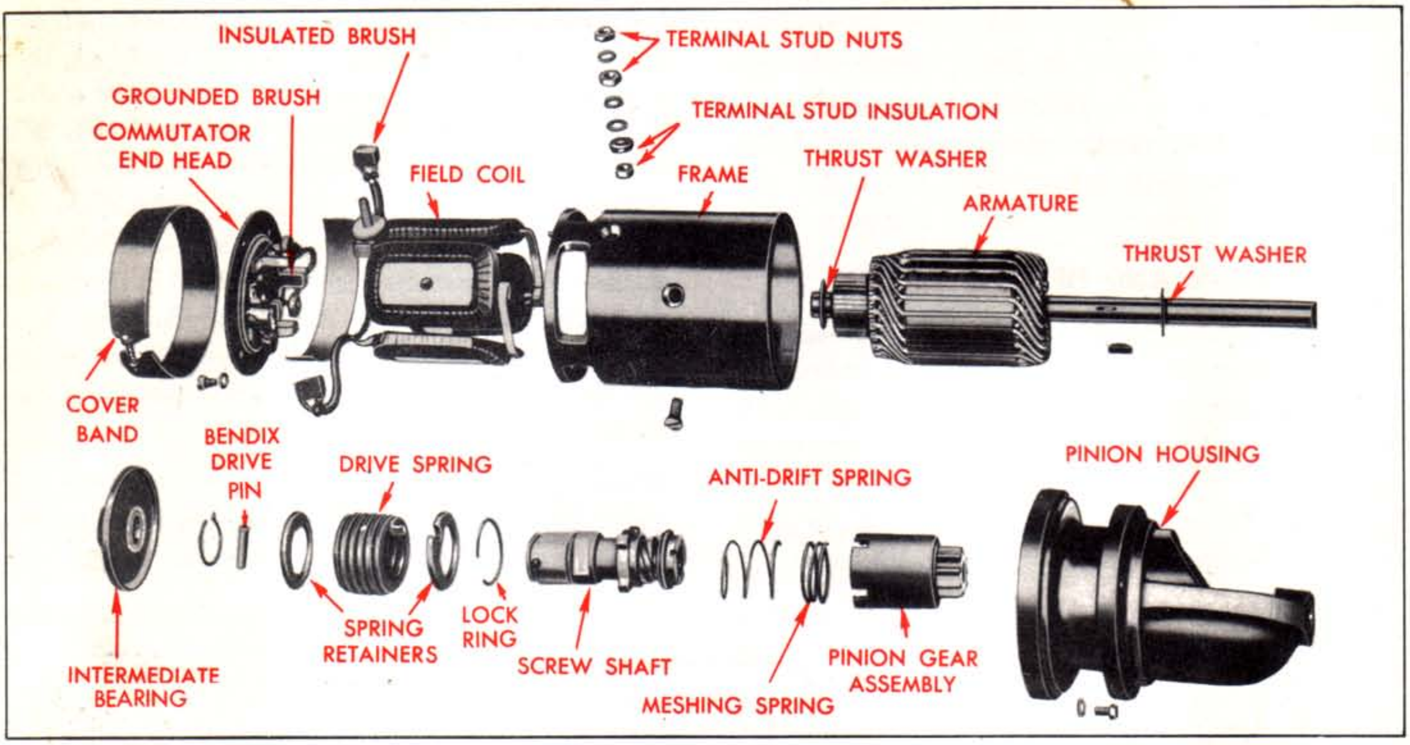


FIGURE 24—EXPLODED VIEW OF STARTING MOTOR WITH BARREL TYPE BENDIX. The above illustration shows the various parts of a typical starting motor. Each part is in its correct relation to the others , however, the motor has been "exploded" to show each part clearly.

sharp blows with a rubber hammer to settle and align the pole shoes. Also be sure the pole shoes are installed in the same location and direction as they were originally. On some motors the shoes are bored after assembly and when they are interchanged they may interfere with the armature. On others the two tips of the shoes are not alike, however, on this type the long tip is always the trailing edge.

If the brushes are oil soaked or are worn to less than ½ their original length they should be replaced. To remove the brushes unsolder and unclinch the lead from the field coil or connector. Insert the new brush lead to its full depth and insert the equalizer lead where used. Clinch tightly then solder to make a low resistance connection. Do not use acid for soldering flux as it will damage insulation. Use a rosin and alcohol solution.

On corrosion resistant motors and also heavy duty units, the field coils and inside of the frame should be brushed with air drying insulating varnish. Allow as much varnish to soak into the field coils as possible but be careful not to soak the brush leads as they must be flexible after the varnish dries. Clean all varnish from the threads and head seats then allow the varnish to dry.

COMMUTATOR END HEAD INSPECTION

Clean the commutator end head thoroughly being careful not to soak the brushes in solvent. Inspect for a bent, cracked or distorted head and replace if these conditions are present.

Place the armature in a padded vise and install the commutator end head on the end of the armature shaft. Do not clamp the armature tightly as this distorts the laminated core. Feel the fit of the bearing on the shaft. If side play is excessive, the bearing or shaft is worn and should be replaced. Where the bearing is replaceable it should be pressed into place with the correct arbor as the arbor determines the inside diameter of the bearing. If the bearing is not removable replace the complete head.

With the head mounted on the armature as above, install a spare brush in one of the holders. Inspect to make sure the brush is parallel to the commutator segments and that it moves freely in the holder. To align the brush it is necessary to install a new arm on swinging type holders, or to replace the complete head or brush plate if the brush holders are the box type. Measure the brush spring tension with a spring scale hooked under the brush screw or under the spring near the end depending upon the type construction. See figures 34 and 35. Pull the scale on a line parallel to the edge of the brush and take the reading just as the spring leaves the brush on the type illustrated in figure 34 or just as the brush leaves the commutator on the type illustrated in figure 35. Adjust the tension by bending the brush spring at the point where it is clamped by the brush holder. Repeat this brush alignment, movement and tension inspection for all brushes. Be sure to remove the brushes from the holders before taking the head off of the armature as they may become chipped or cracked when snapping off of the commutator.

If the brush leads are broken or frayed or if the brushes are oil soaked, chipped, cracked, or worn to less than ½ their original length the brushes should be replaced.

Brushes that are soldered to the field coils or connectors should be replaced as described previously under frame and field inspection. Brushes that have the ground terminal riveted under the brush holder, should have the lead unsoldered and the terminal unclamped. Insert the lead to its full depth in the terminal and clamp tightly. Solder to make a strong, low resistance connection using a high temperature solder and a rosin flux. Do not use acid.

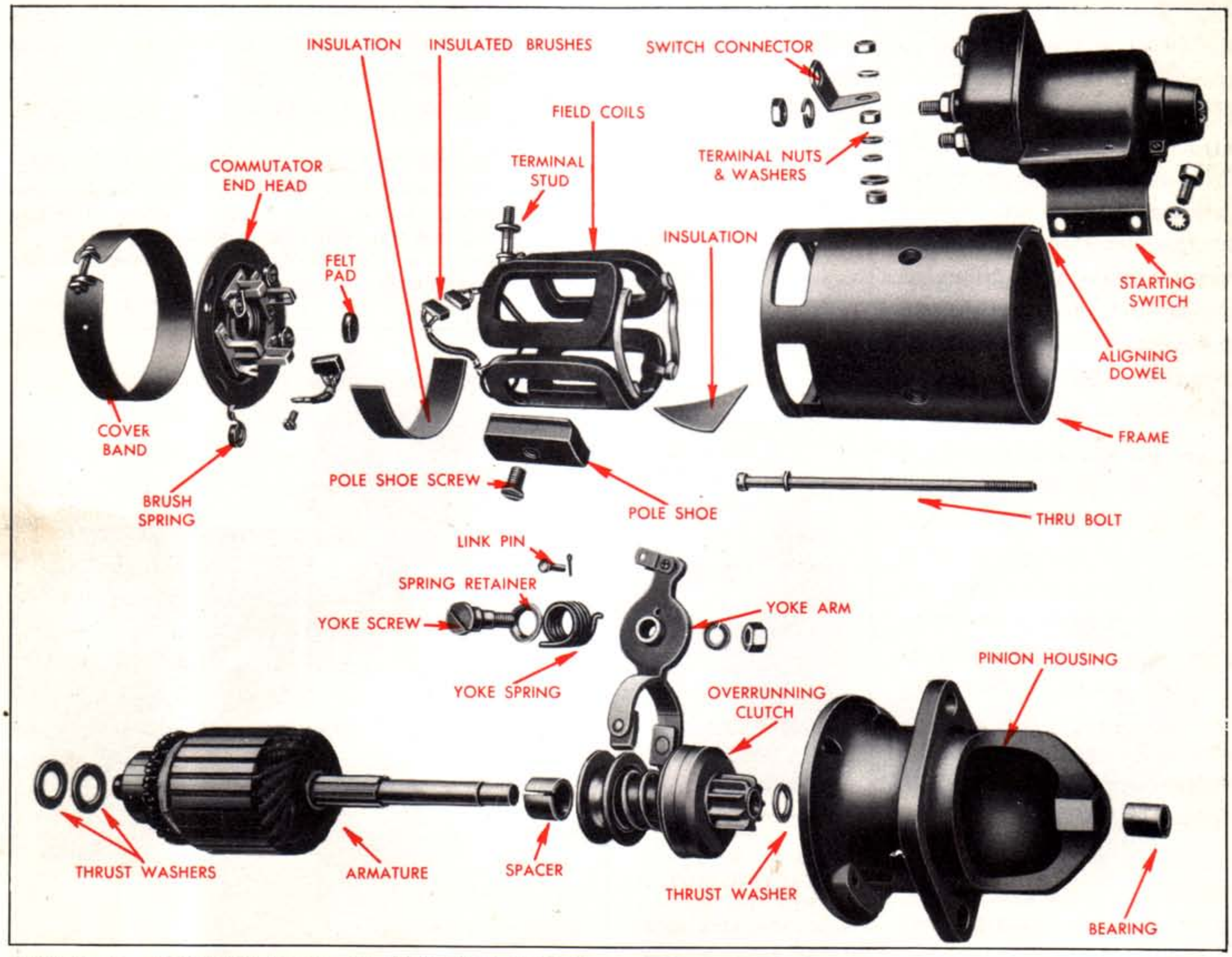


FIGURE 25—EXPLODED VIEW OF STARTING MOTOR WITH SOLENOID OPERATED OVERRUNNING CLUTCH.

This is another exploded view showing the parts used in a typical overrunning clutch motor.

BENDIX DRIVE INSPECTION

Disassemble the drive and clean with kerosene. Clutch type drives and some of the screw shaft assemblies have special lubrication which cannot be replaced. These parts should not be dipped in cleaning fluid but should be cleaned with a brush slightly dampened in kerosene. It is recommended that clutch type drives be cleaned and inspected as a unit and no attempt made at disassembly or adjustment. This type of drive should be returned to the factory for any repairs or adjustments.

Inspect each part for wear and distortion and replace any part not in good condition. Assemble the drive using new spring screw lockwashers and install the washers with the turned up lip hooked in the drive spring loop. After completion of the inspection and installation of the drive on the armature shaft, these lockwashers should have the other lip bent tightly against a flat side of the screw head to prevent any possibility of becoming loose. When assembling the drive do not force the parts together as all parts are designed for free movement and any restriction may cause failure of the drive to function. Locate the cause of the restriction and correct it before completion of the assembly.

Lubricate the armature shaft and screw threads sparingly with a good grade of S.A.E. No. 10 oil. If the starting motor is to be operated under dusty conditions such as on a tractor or other farm equipment this lubrication should be very light or even omitted entirely as the dust and oil would form a gum, restricting the operation of the drive.

Install the drive on the armature shaft making sure it slides easily without restriction. Be sure the keys are in place, where they are used, and tighten the spring screws so that the head spring screw enters the hole in the shaft. Clinch the lockwashers or install any pins and lock rings used on some types of Bendix drives and inspect the installation to make sure the drive is ready for service.

Push on the pinion assembly to compress the drive spring. The screw shaft should move freely on the armature shaft without restriction and should return to its original position when released. This longitudinal movement should be ¼″ to 5⁄16″ depending upon the type of drive. If there is too little movement or if there is restriction, the drive may not mesh properly when using the starting motor.

OVERRUNNING CLUTCH INSPECTION

Clean the outside of the drive with a brush or cloth dampened in cleaning solvent. Do not soak the drive as the clutch mechanism cannot be relubricated. Inspect for wear and make sure the clutch slides easily on

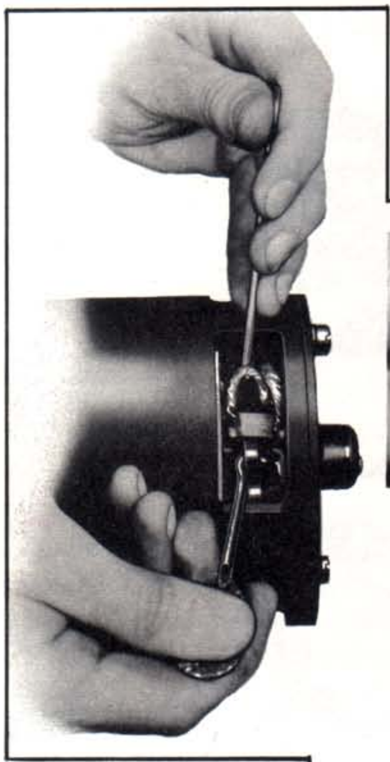


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FIGURE 26—REMOVING STARTING MOTOR BRUSHES. The use of a common wire hook to lift the brush spring and raise the brush is shown by this figure.

FIGURE 27—DISCONNECTING BRUSH LEAD FROM SWINGING TYPE BRUSHES. When disconnecting the lead do not remove the screw entirely as the brush may fall into the motor.
Also do not allow the brush to snap down as it may become cracked.

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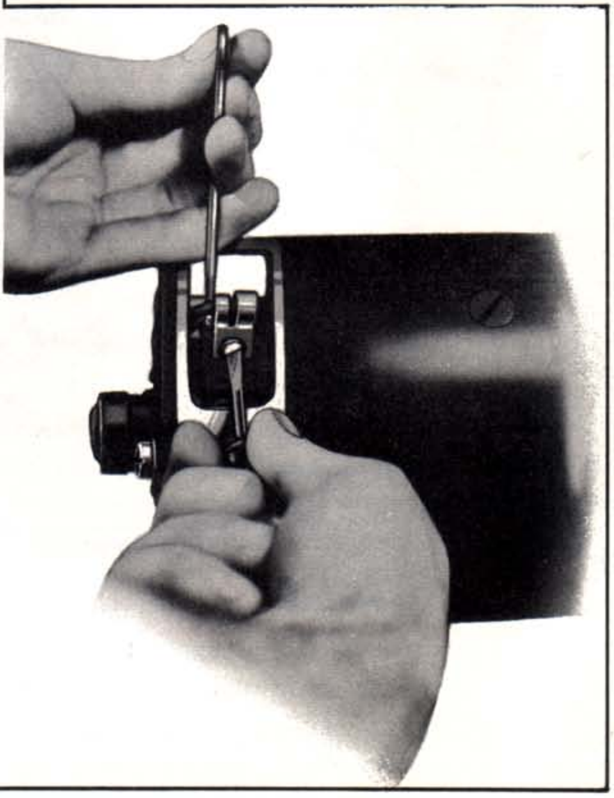


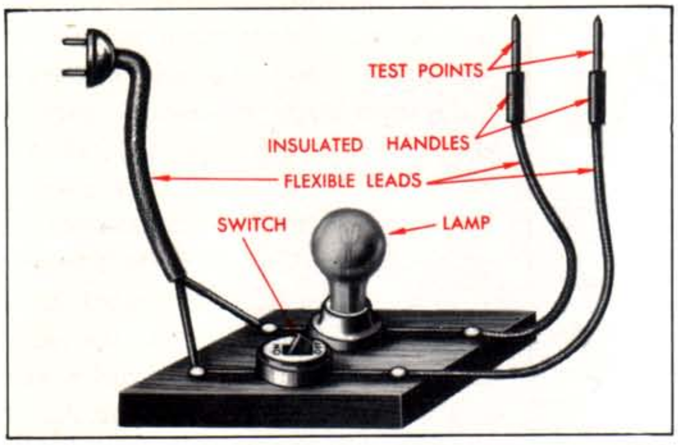


FIGURE 28—TEST PROBES. This illustrates a simple test light for use in making continuity and ground tests.

the armature shaft. Replace the drive if the pinion is worn badly or if the internal splines are damaged.

Place the drive on the armature shaft and turn the pinion. The clutch should release and the pinion turn smoothly though not necessarily freely. Reverse the direction of rotation. The clutch should immediately lock and unlock each time the direction of pinion rotation is changed. If the clutch action is sluggish or restricted replace the drive assembly.

Lubricate the armature shaft sparingly with S.A.E. No. 10 oil.

PINION HOUSING OR DRIVE END HEAD INSPECTION

Thoroughly clean the head or housing and inspect for cracks. Try the fit of the armature shaft in the bearing and replace the bearing if the side play is excessive. Be sure to support the housing so that it does not twist and damage the bearing. Install a new bearing if necessary using the correct arbor as it is designed to give the proper inside diameter to the bearing.

Soak the bearing in S.A.E. No. 10 oil and remove the excess oil from the housing or head.

ASSEMBLY

Soak bronze bearings and felts in S.A.E. No. 10 oil and apply a light film of oil to the shaft bearing surfaces. Remove the excess oil as too much lubrication may deposit on the brushes, commutator, fields or armature, impairing their operation and possibly causing failure.

On gear reduction motors add ½ ounce high temperature, non-fibre gear grease to the gear chamber.

When assembling the yoke on overrunning clutch type motors, be sure the yoke shoes are installed with the curved edge toward the pinion end of the clutch. See figure 36. Install the switch and its linkage making sure all linkage operates freely and that the clutch shifts to its full mesh position. Also check to make sure armature turns easily with only the brush drag restricting its movement.

When assembling the commutator end head on some motors it is possible to have the head rotated from its correct position. This changes the brush position and on some types causes the motor to turn in the wrong direction. On other types the motor may not operate in either direction. The safest way of insuring against this difficulty is to mark the head and frame before disassembling so that they can be installed in their original position.

MOTOR INSPECTION

Bendix Drive Types

Check the clearance between the Bendix drive stop and the inside of the pinion housing as shown in figure 37. This clearance should be 1/16″. If it is not 1/16″ make sure the motor and Bendix are correctly assembled and install thrust washers just inside either the intermediate bearing or the commutator end head as required. This affects the end play which should be checked at the same time.

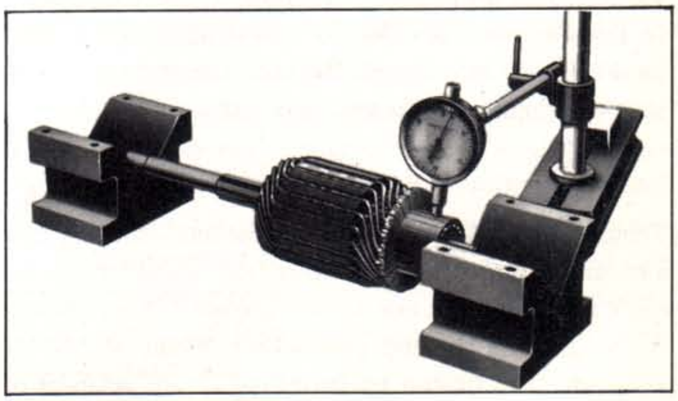


FIGURE 29—MEASURING COMMUTATOR RUNOUT. Figure 29 shows the use of "V" blocks and a dial indicator to measure for out-of-round commutators. The indicator reads in thousandths of an inch and tells the total runout of the commutator.

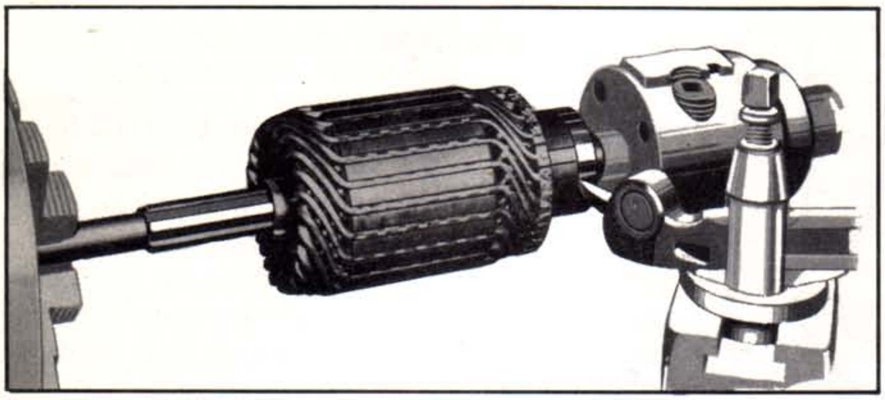


FIGURE 30—TURNING STARTING MOTOR COMMUTATOR ON A LATHE. When truing up the commutator with a lathe take light cuts until no worn or bad spots appear then remove all burrs with 00 or 000 sandpaper.

Measure the clearance between the drive stop and housing as described above with the armature pressed to its two extreme positions. The end play will be the difference between the two readings and should be at least .005″. Do not compress the Bendix drive spring when measuring clearance.

If the motor end play is less than .005″ inspect for improper assembly and make sure all washers are in their correct location. If end play is excessive it can be reduced by installing thrust washers just inside the intermediate bearing or commutator end head. When installing washers, be sure that the brushes are centered on the commutator and the pinion "at rest" position is correct.

Measure the distance from the face of the motor mounting flange to the outer edge of the pinion. This dimension is taken with the pinion screwed back to a point where it just drops off of the spiral. Make adjustments in this "at rest" position by installing thrust washers as previously mentioned. Recheck the end play, drive stop clearance and "at rest" position.

Overrunning Clutch Type

Thrust the armature toward the commutator end then measure the clearance between the shoulder on the shaft and the drive end thrust washer. This clearance is the same as the end play which should be .005″ to .030″ and is adjusted by installing thrust washers on the shaft just inside the commutator end head. These washers may be steel, fibre or leather and should be placed with the hardest material next to the head.

Inspect the switch according to another part of this chapter then install it on the motor. Connect the yoke linkage to the plunger screw on solenoid operated clutches but do not install the lock pin. Shift the pinion into full mesh position by pressing on the solenoid core on electrically operated shifts, or by pressing the yoke lever on manually operated shifts. Measure the distance from the outer edge of the pinion to the thrust washer just inside the drive end bearing. Adjust to the specified full mesh clearance by screwing the plunger connecting screw in or out as necessary on solenoid operated shifts. On manually operated clutches adjust by screwing the switch plunger in or out.

MOTOR TEST

On most motors the terminal stud is accessible and the motor can be connected for test without the switch in the circuit. However, on motors with a manually shifted clutch, the switch should be removed before making the electrical tests.

Connect the motor terminal and frame to a battery of the motor rated voltage and operate on "no load" for two or three minutes to "run in" the brushes. Stop the motor and remove the burrs from the commutator with 00

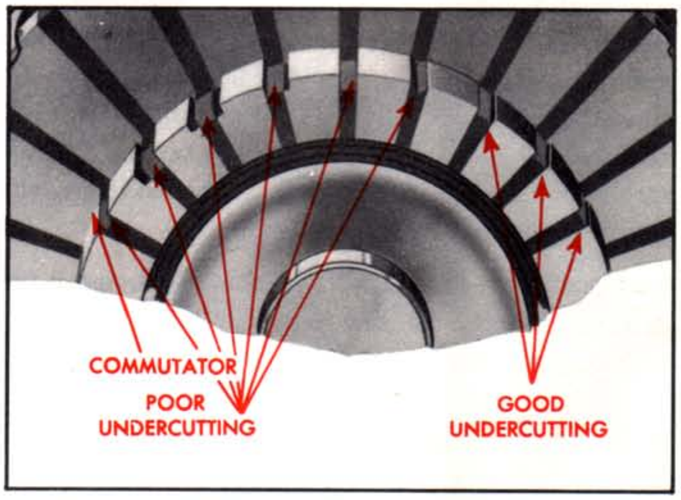


FIGURE 31—SAMPLES OF COMMUTATOR UNDERCUTTING. Good undercutting should be .002″ wider than the mica, 1/32″ deep and exactly centered so that there are no burrs on the mica. There will be slight burrs on the copper but these can be removed after the brushes are seated.

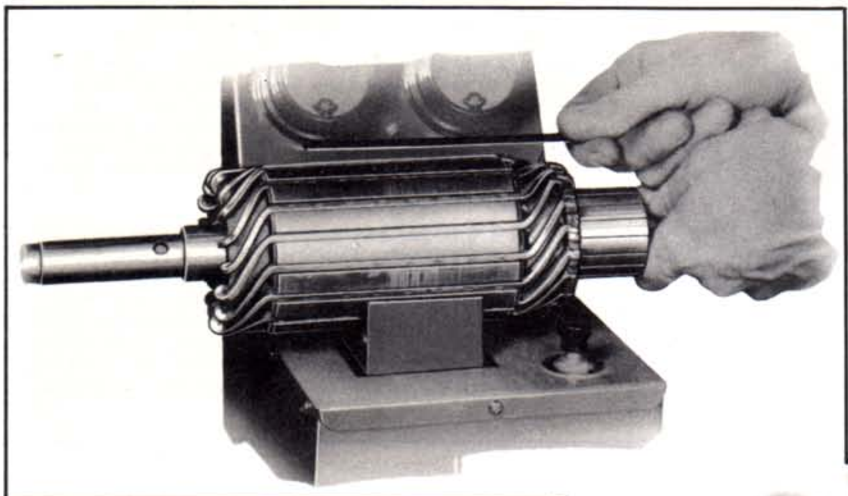
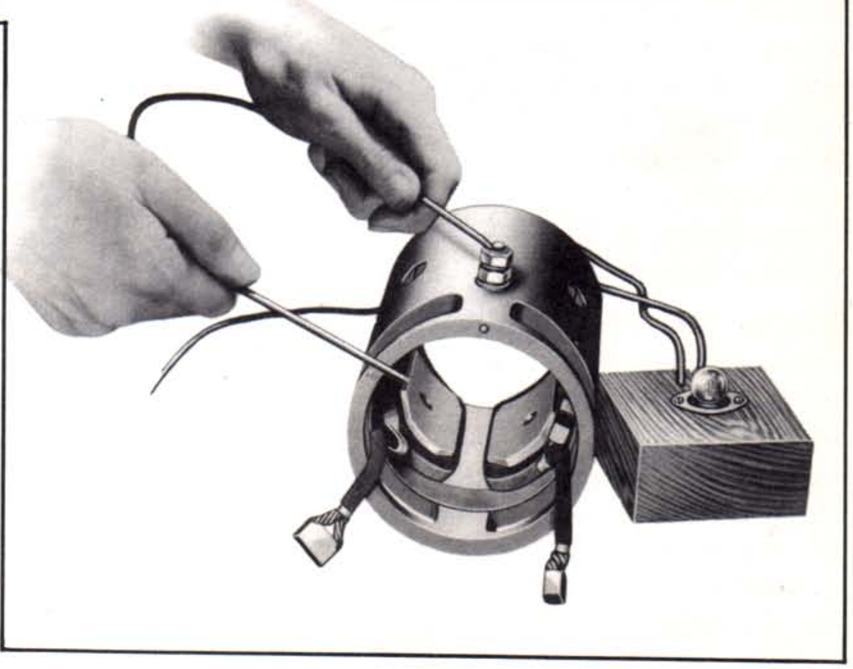


FIGURE 32—ARMATURE SHORT TEST WITH GROWLER. This shows the use of an open core transformer (growler) and a steel strip to test starting motor armatures for shorts. The armature is turned slowly and if a short is present the steel strip vibrates rapidly.

FIGURE 33—TESTING FIELD COILS FOR GROUNDS. The use of the test probes to check for grounded field coils is illustrated here. A 6 volt test lamp is illustrated, however the test light shown in figure 28 can also be used. If a ground is present the lamp lights.



sandpaper then blow out all dirt with clean compressed air. If the motor will not operate, check the internal connections and inspect for shorts and binding.

Check the "no load" current and speed. To test, connect the motor and meters as illustrated in figure 23. The ammeter and shunt should have a capacity well above the specified "no load" current so that it will not be damaged in case the armature does not turn freely. Adjust the carbon pile rheostat to give the specified voltage and read the ammeter. Place a tachometer against the drive end of the armature shaft and read the free running speed while operating at the specified "no load" voltage. Inspect the brush action to make sure the brushes do not arc excessively and that the brushes do not bounce or move. Check the Bendix to make sure the pinion shifts each time the motor is started.

If arcing is excessive or if the current and speed are only slightly low operate the motor on "no load" for a short period to "run in" the brushes and secure a perfect brush fit. Allow the motor to cool then recheck the "no load" draw and speed.

If brush movement is excessive check the brush spring tension and commutator runout as previously described. It is not necessary to disassemble the motor to check the brush spring tension but disassembly is required to check the commutator.

If the Bendix pinion does not shift instantly without sluggishness, the motor must be disassembled and the Bendix carefully checked and inspected as previously outlined.

If the current and speed are both low it is an indication of high resistance in the internal connections. This may be in the brush contact with the commutator, which can be corrected by cleaning the commutator and running in the brushes as described above. High resistance can also be caused by failure to properly crimp and solder the brush and field connections. In rare instances, high resistance may be present between the commutator end head and the frame. This may be caused by corrosion, oil, rust, or by the varnish treatment used on the field coils and commutator end heads to prevent corrosion. If such a condition is found in the commutator end head, also check the mounting of the drive end head or pinion housing for high resistance as most motors are grounded by a flange on the drive end, and the ground circuit passes from the commutator end head through the frame to the drive end head or housing.

If the current is high and the speed low it is an indication of a drag on the armature which may be caused by worn bearings, bent shaft, insufficient end play or by excessive brush tension. These points should be checked and faulty parts replaced or repaired.

If the speed is high and the current is low it is usually an indication of proper operation of the motor but in some cases this condition can be present with a field coil that has had some of the turns shorted out. If such a condition is present it will be indicated by a low stall torque which is to be checked later.

If the "no load" speed and the current are unusually far from the specified figures it is an indication of a grounded, shorted or open circuit, in either the fields or armature and the motor should be disassembled and the fields and the armature checked as previously described.

Check the stall torque. To check,connect the motor as for "no load" test except change the ammeter shunt to give sufficient ammeter capacity to more than handle the stall current. Connect a torque arm and spring scale to the motor as illustrated in figure 38. Close the switch; adjust the carbon pile to give the specified voltage, and read the ammeter and spring scale. The stall torque will be the product of the spring scale reading in pounds multiplied by the length of the torque arm in feet.

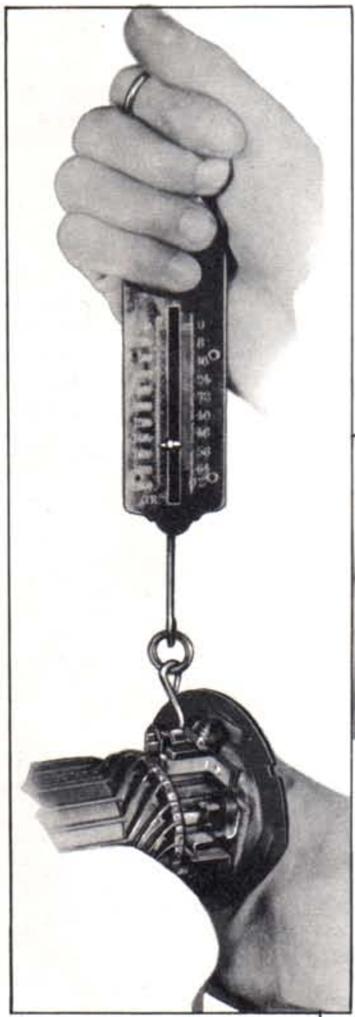


FIGURE 34—MEASURING BRUSH SPRING TENSION—REACTION TYPE BRUSHES. Hook the scale under the brush spring near the end and pull on a line parallel to the sides of the brush. Take the reading just as the spring leaves the brush. To assist in telling the exact instant that the pressure is relieved a small strip of paper can be placed under the brush. Pull slightly on the paper and the paper will slip out at the correct instant for reading the spring scale.

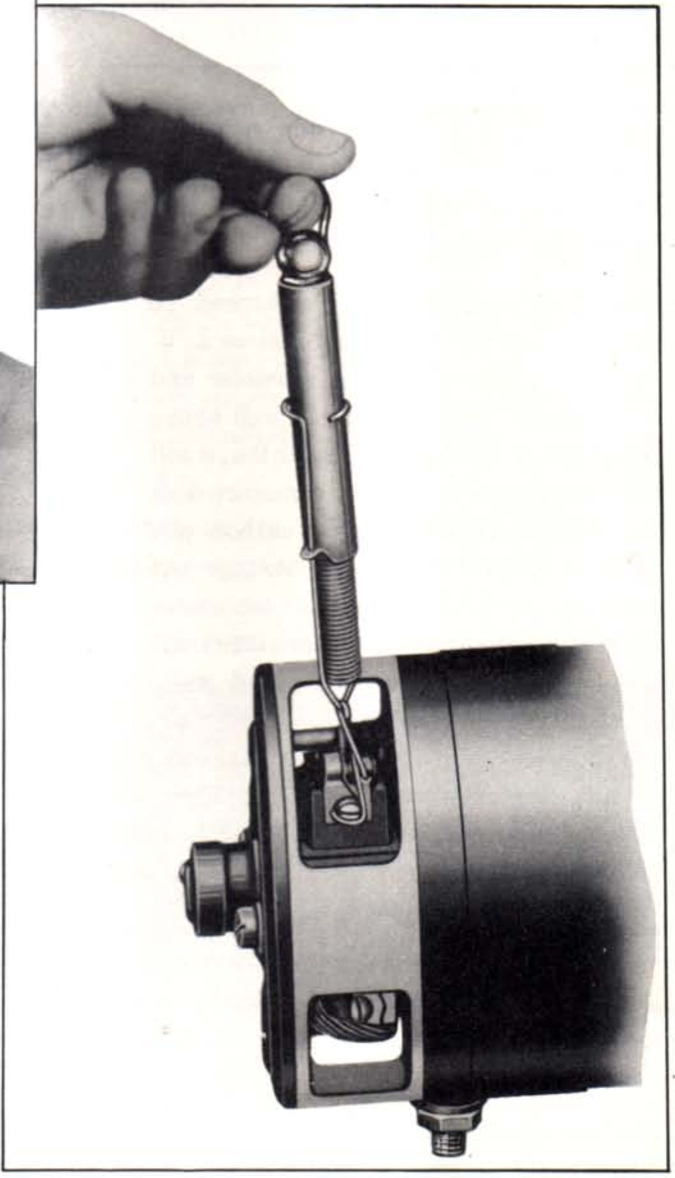


FIGURE 35—MEASURING BRUSH SPRING TENSION—SWINGING TYPE BRUSHES. Hook the spring scale under the brush screw tight against the brush and pull on a line parallel to the sides of the brush. Take the reading just as the brush leaves the commutator. Pulling slightly on a strip of paper which has been placed under the brush will indicate when the brush leaves the commutator and the correct instant for reading the scale.

If the current and torque are both low it indicates high resistance in the internal connections or in the brush contact. These conditions and their corrections are described above in the "no load" test. High current with low torque may be caused by faulty armature or field windings which must be detected by diasssembling the motor and inspecting thoroughly as previously described.

When making tests or when connecting a motor that is designed for a two wire system, the same procedure as just described is used except that instead of connecting one of the battery leads to the motor frame, the lead is connected to the second terminal stud.

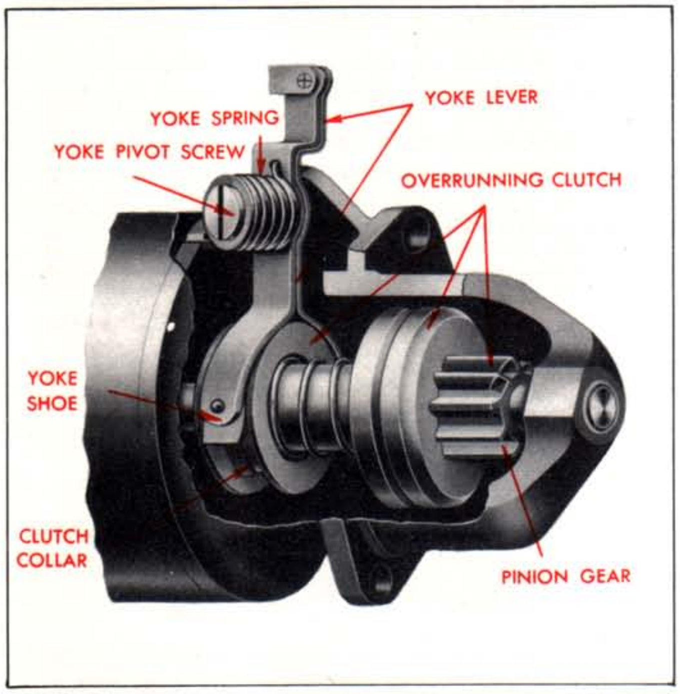


FIGURE 36—ASSEMBLY OF OVERRUNNING CLUTCH AND YOKE SHIFTING LEVER. The main feature of this construction is to make sure the radial sides of the yoke shoes are toward the gear end of the clutch as reversed shoes can cause improper meshing of the pinion.

INSTALLATION

Install the cover band on the motor and clean the outside. Give the motor a coat of air drying enamel on all outside surfaces except the terminal stud, name plate, and the mounting face.

Before installing the motor on the engine, check the battery and starting switch and inspect the starting cables as described in other parts of this chapter. After the motor is installed check the starting circuit for voltage loss as described in the starting circuit wiring.

Clean the mounting faces on the motor and flywheel housing to secure a good ground contact and install the motor on the engine. Connect the leads and pedal linkage making sure that linkage operates freely and that it returns to the "at rest" position when pressure is released. Check the motor operation for proper performance while cranking the engine.

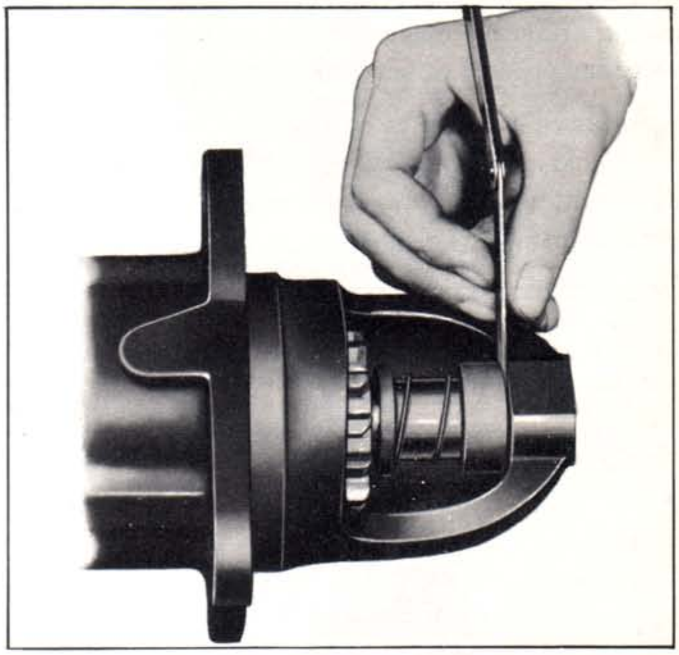


FIGURE 37—MEASURING BENDIX DRIVE STOP CLEARANCE. A common feeler gauge set can be used to make this measurement if there are sufficient gauges to secure the necessary thickness. Do not compress the Bendix spring as this will give an incorrect reading.

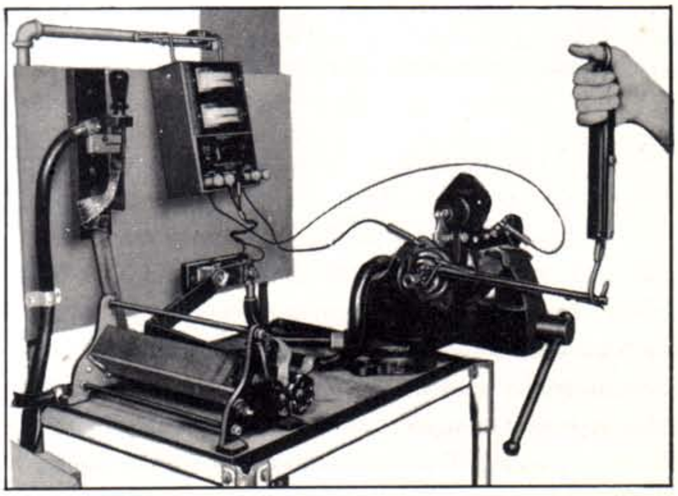


FIGURE 38—MEASURING STARTING MOTOR STALL TORQUE. On the overrunning clutch type motor illustrated it is necessary to shift the yoke lever by hand and tie it in the full mesh position. The switch is not connected in the above circuit which is the same as that used for the no load draw test illustrated in figure 23.

STARTING SWITCH

The starting switch controls the starting motor operation by making and breaking the circuit between the storage battery and motor. It is designed to carry the high currents required by the starting circuit with minimum voltage loss due to contact resistance, and also to make or break the circuit with positive action to reduce arcing and possible switch or motor failure.

Starting switches may be operated by foot or hand, or by solenoid action. Solenoid type switches have a control circuit, usually with a push button switch which is operated manually.

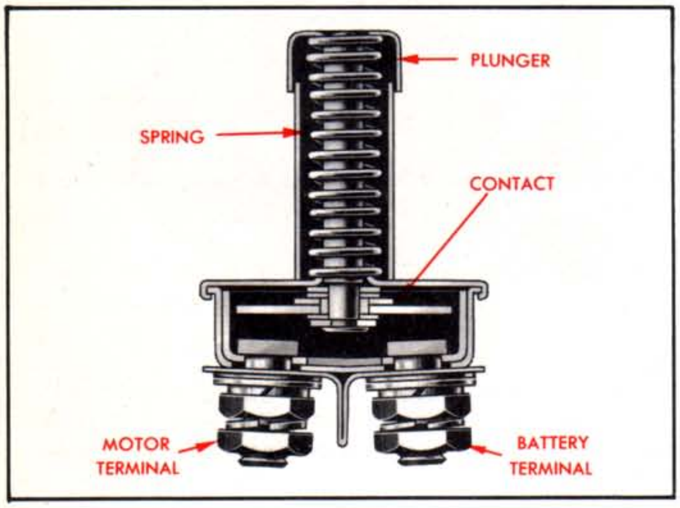


FIGURE 39—MANUAL STARTING SWITCH FOR BENDIX TYPE MOTORS. This type switch has copper contacts on the heads of the terminal studs and uses a copper contact plate. The spring is quite stiff to make the opening of the contacts more positive.

Three types of manual switches are commonly used. One is designed to mount on the floor board or control panel and is actuated directly by the operator. This type is illustrated in figure 39 and has a plunger which carries a contact plate and also two stationary contacts which are connected to the starting motor and battery. The plunger is held in the open position by a spring which is heavy enough to give a clean break when the switch is released. This type switch is used with motors having a Bendix drive or with motors designed for special applications which do not require an automatic drive clutch.

The second type manual starting switch (Figure 40) is used with motors having an overrunning clutch. Its operation is the same as the previous type except it is designed to mount on the starting motor and is actuated by the clutch shift lever. This type is shown mounted on the motor in figure 11. The yoke is moved by pedal action and strikes the switch plunger so that the switch contacts close when the overrunning clutch is completely meshed. On this type, one of the switch contacts is assembled to the starting motor terminal stud, while the other is incorporated in the switch and is connected to the battery terminal stud. Some of these switches have a connection on the side of the switch which is

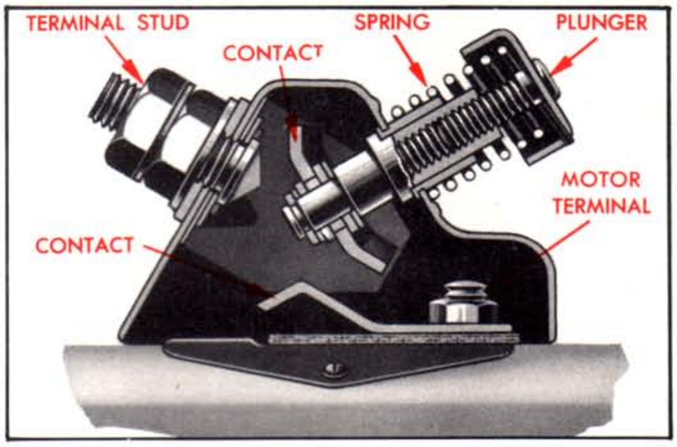


FIGURE 40—MANUAL STARTING SWITCH FOR OVERRUNNING CLUTCH MOTORS. This type switch has a copper contact on the head of the switch terminal stud and another that mounts on the starting motor terminal. The plunger carries a copper plate that strikes the two contacts. The switch is operated by the yoke shifting lever so that the contacts close after the clutch pinion gear meshes with the flywheel.

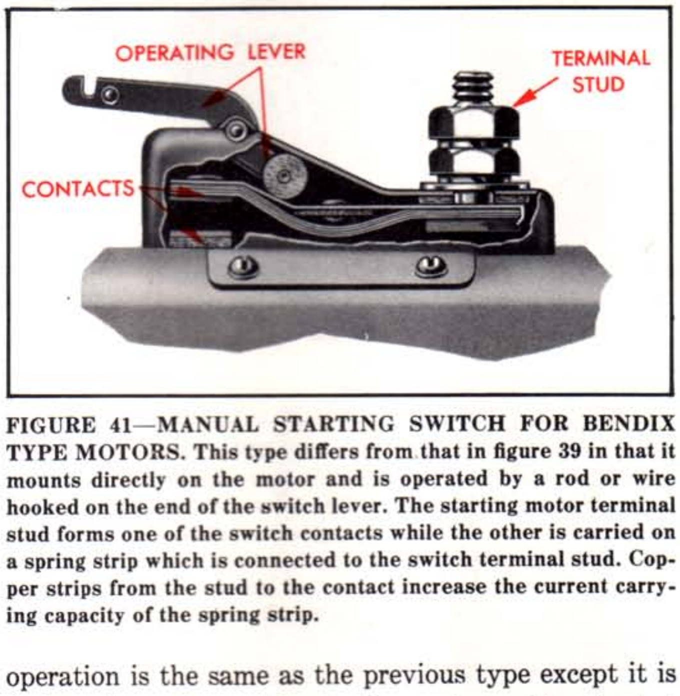


FIGURE 41—MANUAL STARTING SWITCH FOR BENDIX TYPE MOTORS. This type differs from that in figure 39 in that it mounts directly on the motor and is operated by a rod or wire hooked on the end of the switch lever. The starting motor terminal stud forms one of the switch contacts while the other is carried on a spring strip which is connected to the switch terminal stud. Copper strips from the stud to the contact increase the current carrying capacity of the spring strip.

used to supply current to an automatic choke during the starting period.

The third type of manual starting switch is also designed to mount on the starting motor but its operation is controlled by either a rod or wire that is pulled by the operator. This type, (Figure 41) has a switch lever that presses on a spring strip which carries one contact. The other contact is mounted on the starting motor terminal stud while the battery is connected directly to the spring strip through the switch terminal.

Vacuum type starting switches (Figures 42 and 43) are similar in action to the third type of manual switch just described. The switch is operated by direct linkage to the clutch pedal instead of the wire or rod used on the manual type. In order to make the switch inoperative and enable the operator to use the clutch when the engine is running, the manifold vacuum is applied to a diaphragm in the switch. With vacuum on this diaphragm, a latch in the switch is held in the open position and movement of the switch lever does not close the contacts.

Solenoid starting switches close the starting circuit through the magnetic pull of a solenoid on a steel core which carries the contact disc. The contact disc strikes two contacts that are connected to the external circuit. The contact disc on solenoid switches is mounted through a spring to make the opening and closing more positive and to align the disc with the contacts to give full surface contact. The type switch shown in figure 44 is constructed in this manner and has only one purpose that of making and breaking the starting circuit. It is used with motors having a Bendix drive and cannot be used with an overrunning clutch. Solenoid switches may be grounded internally as shown in figure 45 or may be grounded externally by the control button as shown in figure 46. Others may have the winding completely insulated with both ends of the winding brought out to the control terminals as illustrated in figure 47. Many solenoid switches are used as relays in other than the starting circuit.

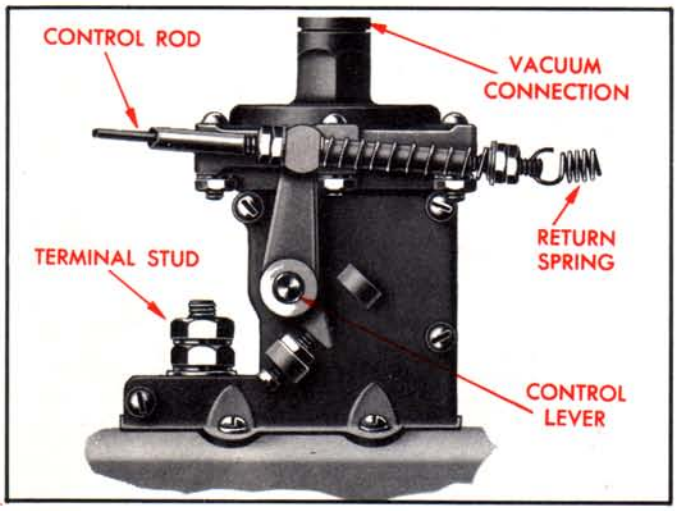


FIGURE 42—VACUUM STARTING SWITCH—EXTERNAL VIEW. The control rod is usually connected to the clutch lever so that the clutch pedal must be depressed to operate the switch. When engine intake vacuum is applied to the vacuum connection a release operates within the switch to make the switch inoperative and allow the clutch to be used.

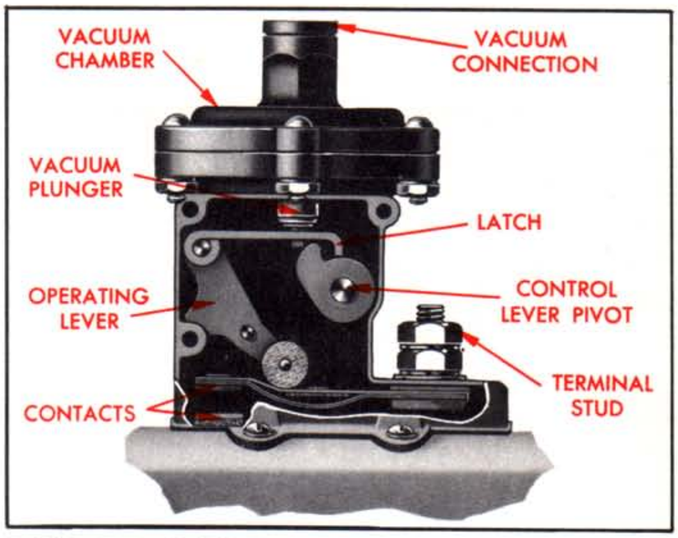


FIGURE 43—VACUUM STARTING SWITCH—INTERNAL VIEW. The control lever is actuated by the control rod shown in figure 42. When it is turned it pulls on the latch and operates the switch lever and contacts. As soon as the engine starts the intake vacuum pulls on the vacuum chamber diaphragm which lifts the latch away from the control lever pivot. This allows the control rod to move without actuating the switch contacts.

A heavy duty solenoid switch has been developed for use with large starting motors such as used on diesel engines. These heavy duty switches operate in the same manner as that just described but have a different construction (see figure 48) which permits disassembly and repair of the components.

Solenoids switches which are used with overrunning clutch motors are designed to shift the clutch pinion gear into mesh with the flywheel, in addition to closing the starting motor circuit. This type, shown in figure 49 and on the starting motor in figure 12, has a large plunger that is linked to the clutch shifting yoke and a small plunger that operates the switch contacts. These plungers do not move simultaneously, as the electric circuit is designed to close after the pinion is in mesh with the flywheel. The internal circuit of the switch is shown in figure 50 and includes a relay, contact disc, 2 plungers and 2 solenoid windings. When the control button is operated, the relay circuit is completed and the relay contacts close. This connects both soleonid windings to the battery and current flows directly to ground through one winding. The other winding is connected to the motor terminal which, when the motor is stopped, is nearly equivalent to a ground due to the low resistance of the internal circuit of the starting motor. Thus current flows through both solenoid windings and creates a pull strong enough to shift the clutch into mesh with the flywheel. When the large plunger is nearly bottomed it strikes the small plunger carrying the contact disc and forces the disc against the terminal contacts. This completes the starting motor circuit and also shorts out one of the solenoid windings. Bottoming of the plunger reduces the current needed to hold the switch closed and one winding can be shorted out without allowing the switch to open. When the control circuit is released,two springs open the switch contacts and shift the clutch into the "at rest" position.

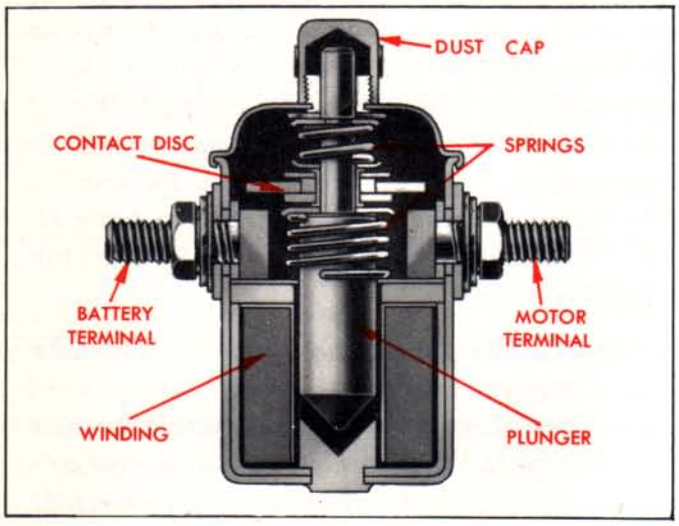


FIGURE 44—SOLENOID STARTING SWITCH FOR BENDIX TYPE MOTORS. The winding of this type switch has many turns of small wire. When it is energized its magnetism pulls on the switch plunger and brings the contact disc against the terminal contacts. The lower spring compresses as soon as the plunger begins to move. The other spring does not compress until the contact disc strikes the contacts Both springs pull against the residual magnetism when the switch is released.

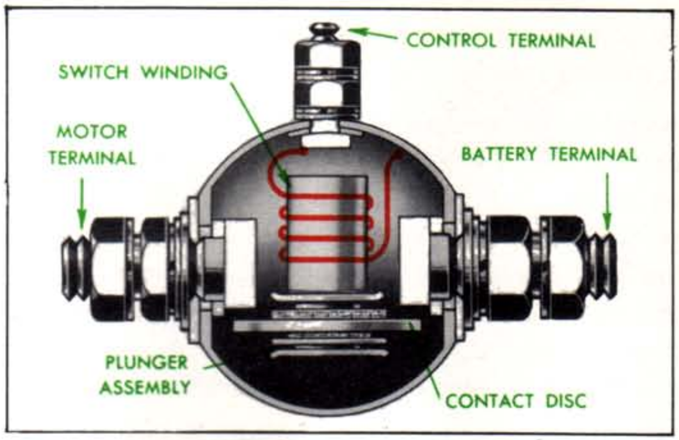


FIGURE 45—SOLENOID SWITCH INTERNAL WIRING—INTERNAL GROUND. This is a schematic diagram of the switch showing the hookup of the switch winding. This type requires the switch base to be grounded to the chassis and the control terminal connected to the battery through the control button.

Since small diesel engines have become more commonly used, starting motors have been developed that have a very large current draw which may be as high as 1000 to 1500 amperes during the first instant of starting. To reduce this initial current and to reduce the sudden shock when the pinion gear meshes with the flywheel, two step starting controls are used.

A push button switch is used with the two step starting control. When the button is depressed two separate sets of contacts are closed simultaneously. These contacts are connected to the starting motor control as illus-

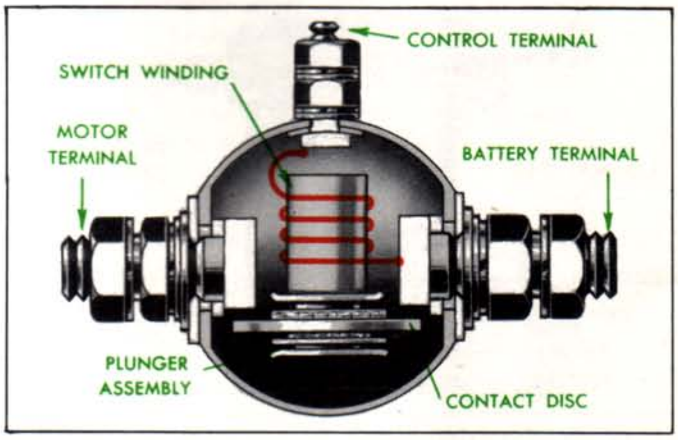


FIGURE 46—SOLENOID SWITCH INTERNAL WIRING—EXTERNAL GROUND. This is a schematic diagram of the switch showing the hookup of the switch winding. It is not necessary to ground the switch base as the circuit is grounded through the control terminal and control button.

trated in figure 51 and complete the circuits to make the control operate. The control box consists of two solenoid switches and a time delay relay. When the push button is operated, one of the solenoid switches closes immediately and connects the starting motor to the battery through a resistor. This resistance reduces the large current that would flow through a stopped motor. The closing of solenoid switch number 1 also short circuits the relay winding thereby de-energizing the relay. After a short time delay, the relay opens the lower contacts and closes the upper contacts which excites the second solenoid switch. When this second switch closes, the resistance is shorted out and full battery voltage is applied to the starting motor.

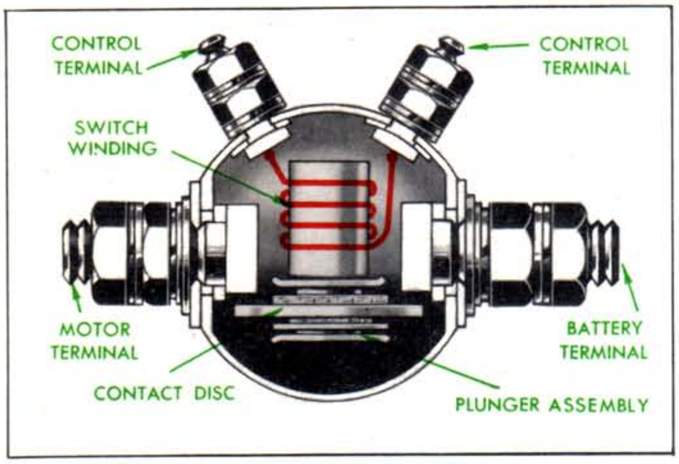


FIGURE 47—SOLENOID SWITCH INTERNAL WIRING—TWO WIRE SWITCH. This type switch wiring is used for two wire systems or where it is desired to connect a second control in the circuit. The most common of these control circuits connects one control terminal to the battery through the control button and grounds the other through the generator armature. This makes the switch inoperative whenever the generator is charging.

STARTING SWITCH MAINTENANCE

The starting switch requires no periodic maintenance other than an inspection to see that it is mounted firmly and that all connections are tight.

If the starting motor fails to crank the engine or, if it cranks too slowly, the starting switch, motor, battery and cables should be checked to find the cause. Consult other parts of this chapter for the inspection procedure on the starting motor, battery and cables.

To check the starting switch, turn off the ignition and make a connection from the starting switch battery terminal to motor terminal. Use a heavy battery cable to make this connection as a small wire would become overheated and burn. If the motor cranks the engine with this lead held against the switch terminals it indicates that the switch or the switch control circuit is at fault. To check for high resistance in the switch contacts connect a voltmeter from the switch "battery" to "motor" terminals and crank the engine in the normal manner. Have solenoid switches closed electrically by operating the push button and not by pressing the emergency button provided on some types. If the voltage drop exceeds .20 volt for each 100 amperes flowing (consult the motor test specification for the current which will be about 80% of the stall current specified

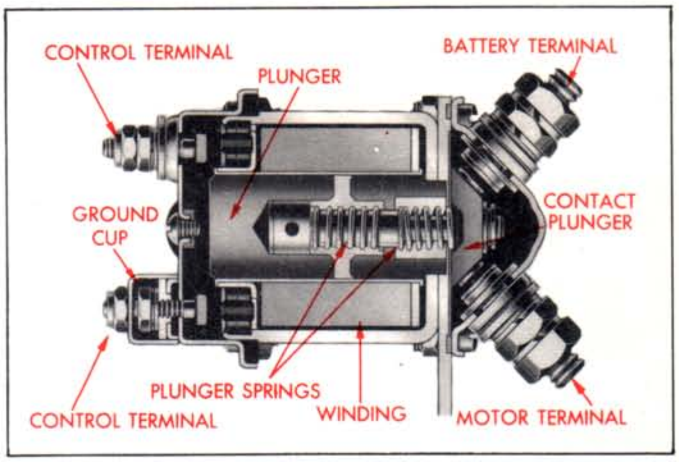


FIGURE 48—HEAVY DUTY SOLENOID SWITCH. This switch is similar to that shown in figure 44, however its construction permits disassembly and replacement of the contacts which are made of special alloy. The internal circuit of this switch is the same as that shown in figure 47 except that one of the control terminals is grounded by a cup placed under the terminal nut.

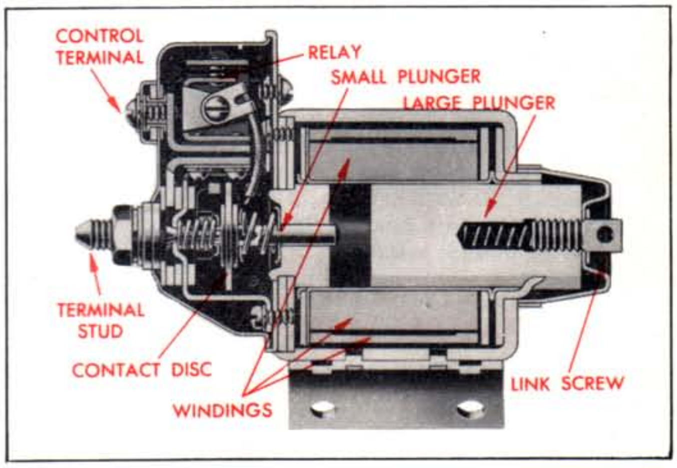


FIGURE 49—SOLENOID SWITCH FOR OVERRUNNING CLUTCH TYPE MOTORS. This switch mounts on the starting motor and has the large plunger linked to the clutch shifting yoke. The small plunger carries the contact disc and is moved into contact when the large plunger bottoms and strikes the end of the rod.

for $\frac{1}{3}$ the rated voltage) it indicates the contacts are burned or corroded or, if the two step type, that the second switch may not be operating.

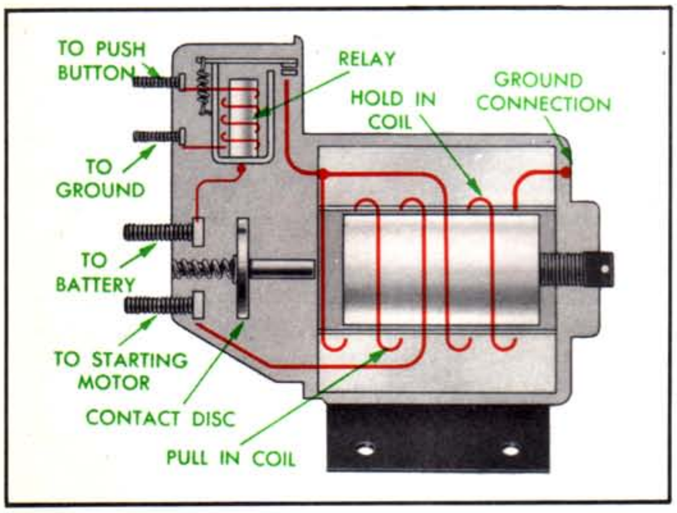


FIGURE 50—SOLENOID SWITCH INTERNAL WIRING—CLUTCH SHIFTING TYPE. The internal wiring of a clutch shifting solenoid switch is shown here. The relay is energized, through the control button and the control terminals and when it closes both solenoid windings are connected to the battery. One of the large windings is grounded to the switch case while the other is grounded through the starting motor. When the switch closes, the "pull-in" winding is shorted out and the "hold-in" winding keeps the clutch in the meshed position.

STARTING SWITCH TESTS

If the above checks indicate that the switch is inoperative or has a high voltage loss, remove the switch from the engine. Tape the battery lead to prevent short circuiting the battery while the switch is unmounted.

Connect a carbon pile rheostat, 500 ampere ammeter and shunt, and a battery in series with the switch load terminals, and connect a voltmeter between the switch load terminals. See figure 52. On solenoid types connect the control terminals to the battery or ground as needed to make the switch close. On manual type switches apply normal pressure to the button or lever. Adjust the current to 100 amperes and read the voltmeter which should be less than .20 volt. If the voltage loss is larger than this, disassemble the switch and clean or replace the contacts or if the contacts are not replaceable discard the complete switch.

Consult the specifications on solenoid switches for the connections to the control circuit. Connect an ammeter, battery and variable resistance in series with the switch control circuit and connect a voltmeter across the circuit. See figures 53, 54, 55, and 56. Adjust the voltage to that specified for the amperage draw of the relay winding on the clutch shifting types or for the solenoid winding on all other types. If the current is not as specified replace the relay or the complete switch.

With the switch connected as above increase the voltage slowly until the switch or relay closes, as indicated by a click, and read the voltmeter. Increase the voltage to the rated value then reduce the voltage slowly until the switch or relay opens and read the voltmeter again. Adjust the relay closing voltage by bending the lower spring hanger and the opening voltage by changing the contact gap. Keep the contacts aligned and do not adjust the contact gap to less than .015″. Where no adjustment is possible replace the complete switch if the closing and opening voltage is not within limits.

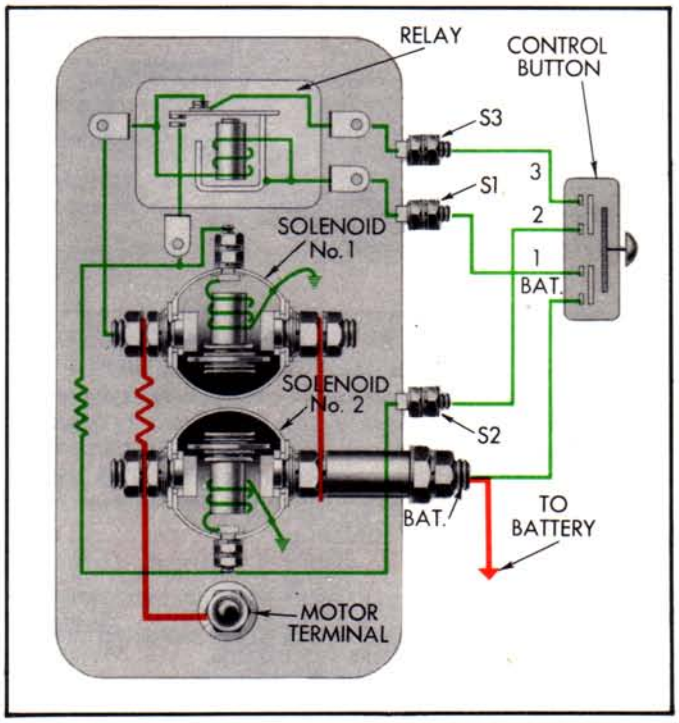


FIGURE 51—TWO STEP STARTING MOTOR CONTROL. When the control button is operated two separate circuits are completed. One circuit excites the relay winding and closes the lower relay contacts. This energizes solenoid switch No. 1 which connects the battery to the motor through the resistance. The closing of solenoid switch No. 1 also short circuits the relay winding, thereby de-energizing the relay. After a short time delay, the relay opens the lower contacts and closes the upper contacts. This excites the second solenoid switch and connects the motor directly to the battery. The first solenoid switch remains closed as it continues to receive enough current through the carbon resistor to keep it in the closed position.

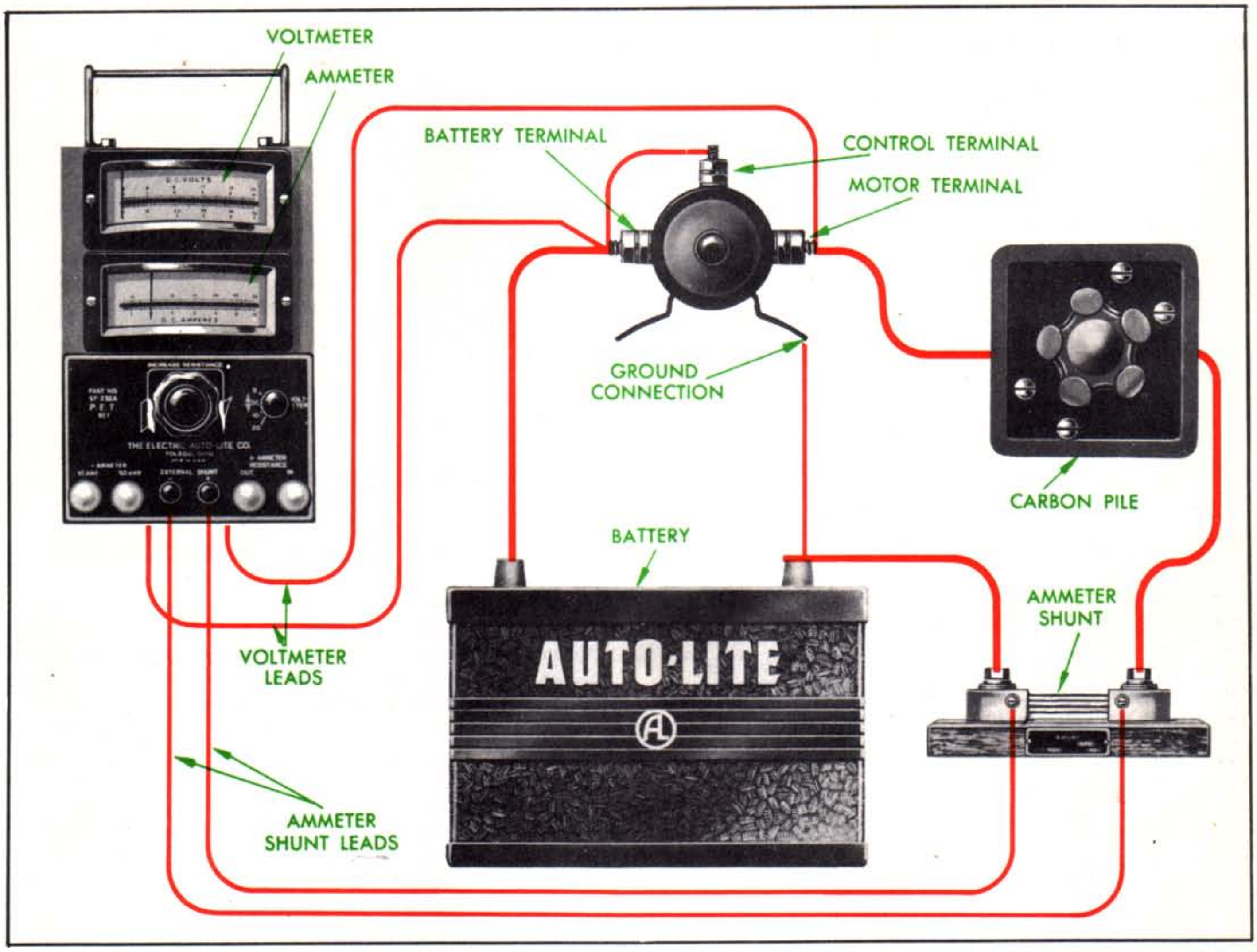
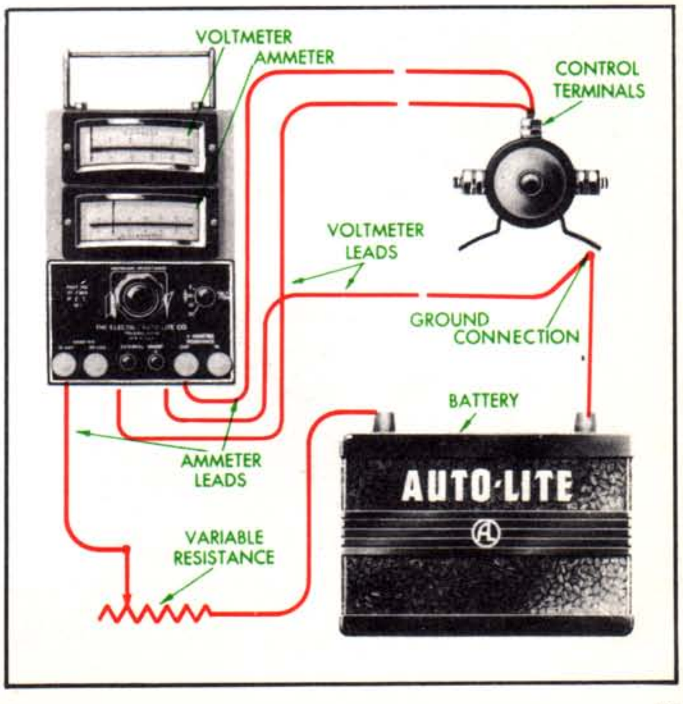


FIGURE 52—SWITCH VOLTAGE DROP TEST CIRCUIT. This diagram shows the circuit used to measure the voltage loss in the switch contacts. The lead from the "Bat." terminal to the control terminal is used to energize the switch winding and make the contacts close. Switches which have the winding connected as in figure 46 should have this lead connected from the control terminal to ground to make the switch close.

FIGURE 53—SWITCH CLOSING AND OPENING TEST CIRCUIT—INTERNALLY GROUNDED. These connections should be made when measuring the coil draw or testing the opening and closing voltages of solenoid switches having internal connections as shown in figure 45.



On clutch shifting solenoids, connect the ammeter, rheostat and battery in series with and the voltmeter across the relay stationary contact and the switch base. See figure 57. Adjust the voltage to that specified for the "holding" coil draw and read the ammeter. Change the connections from the switch base to the switch motor terminal (Figure 58) and adjust the voltage to that specified for the "pull-in" coil. Read the ammeter. If the "holding" or "pull-in" coil draw is not within limits, replace the switch winding assembly.

After assembly of the clutch shifting solenoid switch on the motor it should be inspected for free operation of the plunger and linkage and the pinion "at rest" position should be adjusted as described in the starting motor inspection. No lubrication should be used on the plunger as this would cause dust to collect on the plunger and restrict movement.

TWO STEP STARTER CONTROL TESTS

The two step starter should be disassembled and each part inspected for corrosion or other evidences of inability to function properly. The solenoid switches should each be checked and inspected as described above and the time delay relay operation should be checked as follows:

Remove the relay cover and inspect the contacts. File with a No. 6 American Swiss cut equalling file if necessary and clean with linen tape and carbon tetrachloride. Inspect for damaged insulation and windings. Check the air gap and adjust if necessary by bending the upper stationary contact bracket.

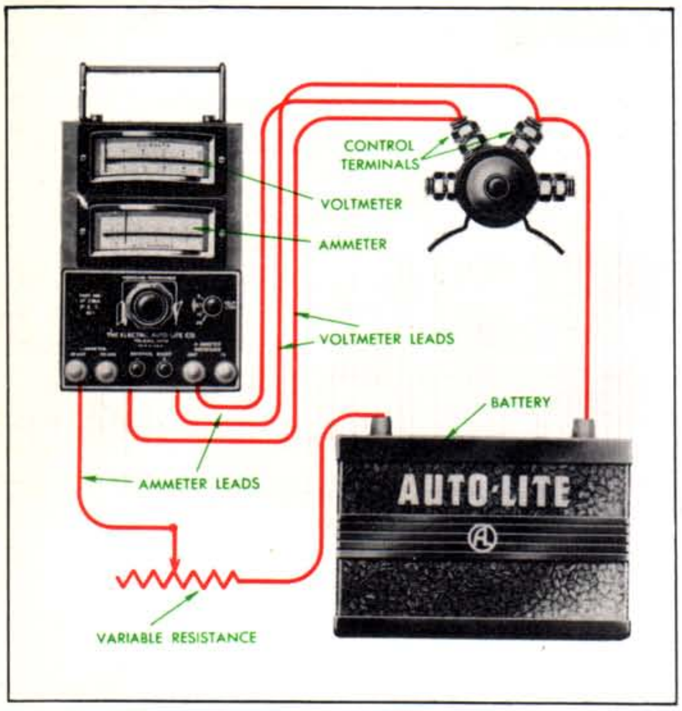


FIGURE 55—SWITCH CLOSING AND OPENING TEST CIRCUIT—2 WIRE SWITCHES. The necessary connections for testing the opening and closing voltages and current draw of 2 wire switches is shown here.

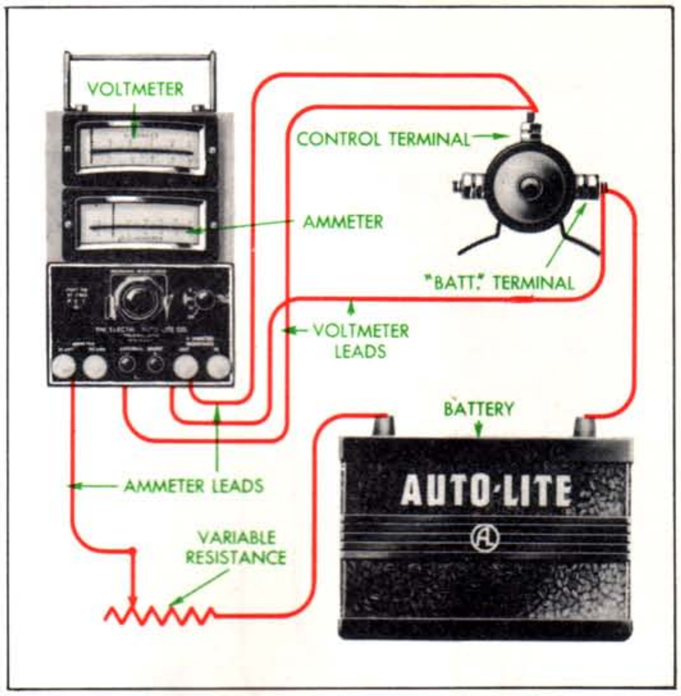


FIGURE 54—SWITCH CLOSING AND OPENING TEST CIRCUIT—EXTERNALLY GROUNDED. These connections should be made when measuring the coil draw or when testing the opening and closing voltages of solenoid switches having internal connections as shown in figure 46.

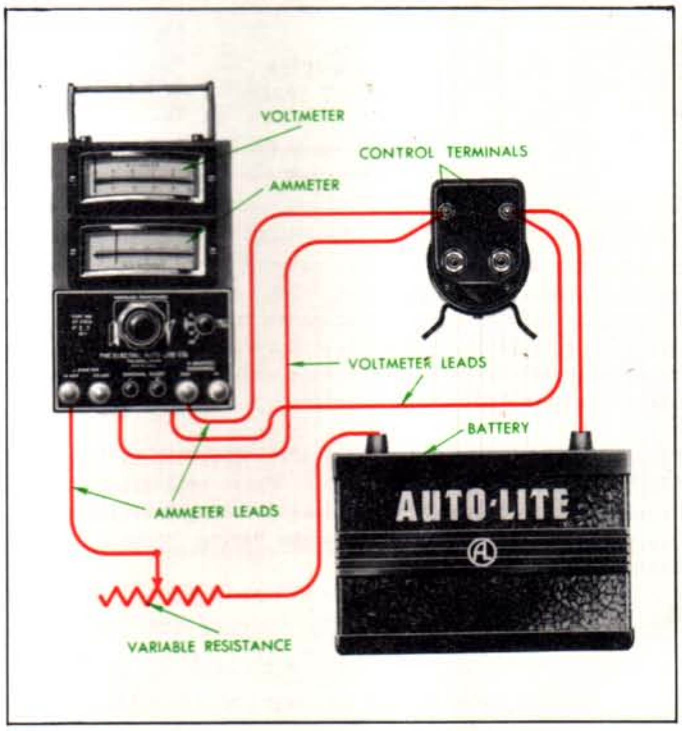


FIGURE 56—RELAY CLOSING AND OPENING TEST CIRCUIT—CLUTCH SHIFTING SWITCHES. This diagram shows the necessary connections for measuring the relay coil draw and for checking the closing and opening of the contacts. To indicate when the contacts are open or closed a test lamp can be connected from the switch "Mot." terminal to the battery.

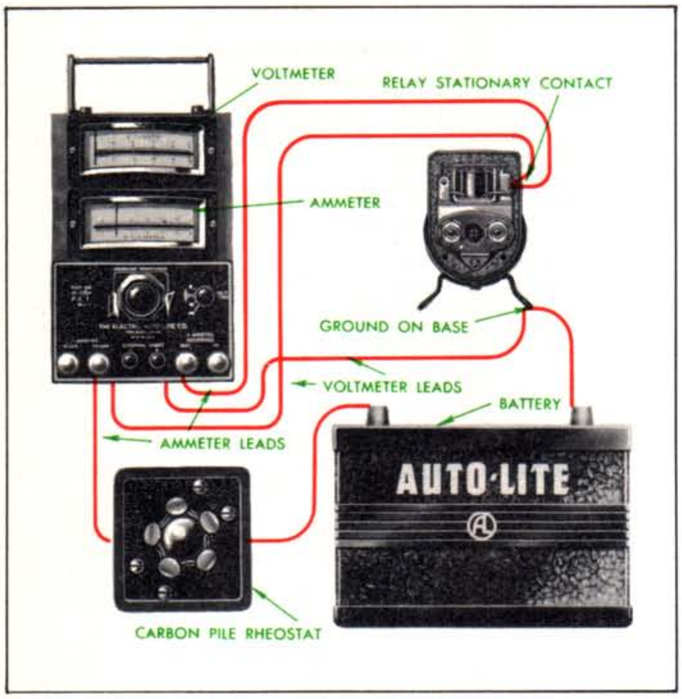


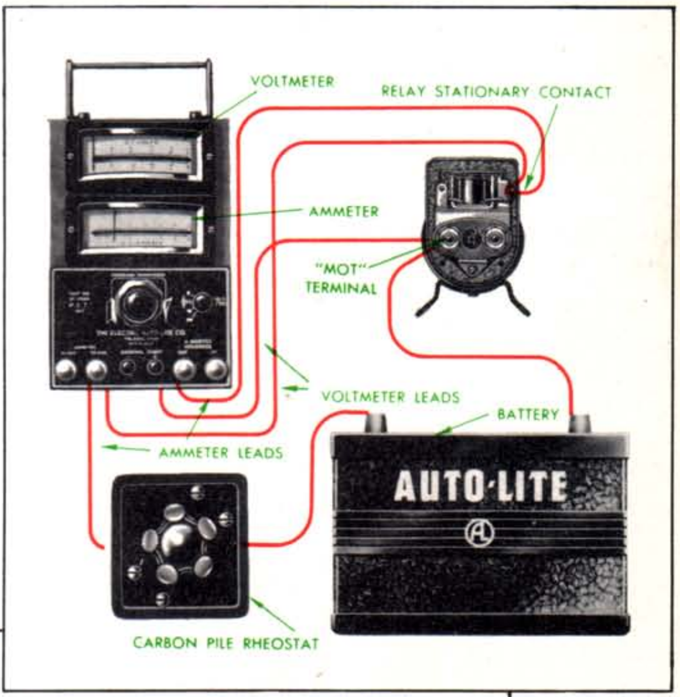
FIGURE 57—TEST CIRCUIT FOR MEASURING "HOLD-IN" COIL DRAW. To test the "hold-in" coil make the connections as indicated. Adjust the resistance to give the specified voltage and read the ammeter.

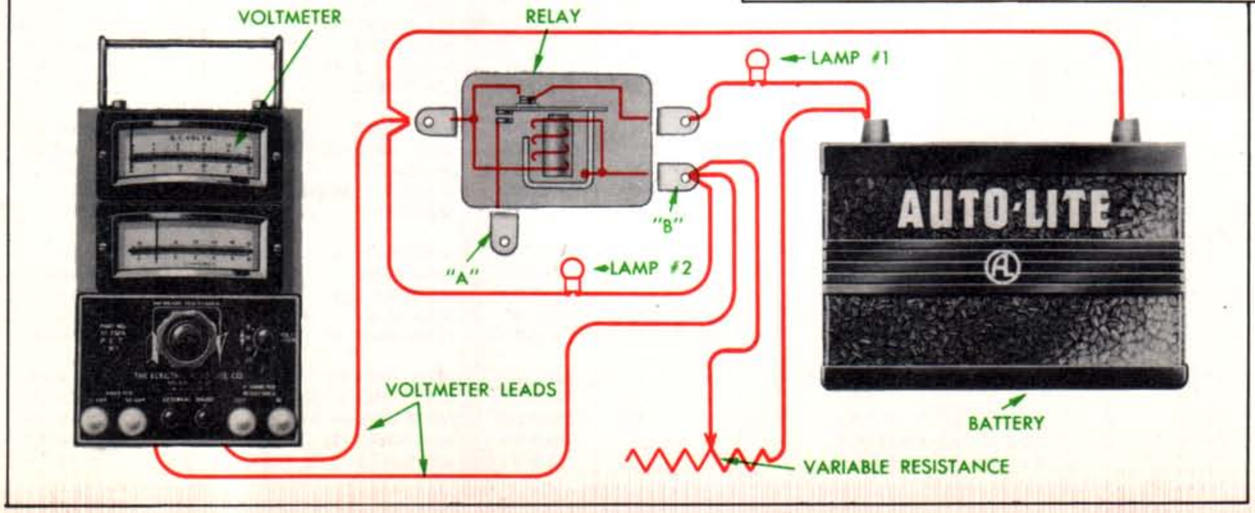
FIGURE 58—TEST CONNECTIONS FOR MEASURING THE "PULL-IN" COIL DRAW. Connect the switch as indicated in this diagram to measure the amperage draw of the "pull-in" winding. The ammeter should have sufficient capacity to handle an overload in case the coil is shorted.

FIGURE 59—CONNECTIONS FOR TESTING TIME DELAY RELAY. For HRG-4001 relay the battery should be six volts and both lamps should be 3 c.p.-6 volt. Lamp No. 1 is the indicator to tell when the contacts open and close. Lamp No. 2 provides a slight load through the variable resistance so that it will control the voltage applied to the winding.

Connect a 6 volt battery, variable resistance, voltmeter and two 6 volt lamps as illustrated in figure 59. Insert all resistance in the circuit. Lamp No. 1 should be lit. Slowly reduce the resistance noting the voltage just as lamp No. 1 goes out. Adjust the voltage by bending the lower spring hanger. Decrease the voltage slowly and note the voltage at which lamp No. 1 goes on. This voltage is adjusted by varying the height of the main stationary contact. Keep contacts aligned. This latter adjustment also affects the time delay of the relay and for a longer delay the opening voltage should be set near the lower limit.

Touch test probes to the terminals marked "A" and "B" in figure 59. The test light should be on when the relay winding is energized.





Starting Motor	Rated Volts	Rotation Drive End	Test No.
DI-1313	6	C	DI-0
DI-1314	6	C	DI-0
DI-1568	6	C	DI-0
DN-1389	6	C	DN-0
MAB-4005	6	C	MAB-0
MAB-4028	6	C	MAB-0
MAB-4030	6	C	MAB-0
MAB-4040, A	6	C	MAB-0
MAB-4044, A	6	CC	MAB-0
MAB-4045, A	6	C	MAB-0
MAB-4046, A	6	C	MAB-0
MAB-4054	6	C	MAB-0
MAB-4060	6	C	MAB-0
MAB-4061	6	C	MAB-0
MAB-4065	6	C	MAB-0
MAB-4066	6	C	MAB-0
MAB-4068	6	C	MAB-0
MAB-4069, B	6	C	MAB-0
MAB-4071	6	C	MAB-0
MAB-4072, A	6	C	MAB-0
MAB-4073	6	CC	MAB-0
MAB-4074	6	C	MAB-0
MAB-4075	6	C	MAB-0
MAB-4076	6	C	MAB-0
MAB-4077	6	C	MAB-0
MAB-4078	6	C	MAB-0
MAB-4080	6	C	MAB-0
MAB-4081	6	C	MAB-0
MAB-4082	6	C	MAB-0
MAB-4083	6	C	MAB-0
MAB-4084	6	C	MAB-0
MAB-4085, A, B	6	C	MAB-0
MAB-4087	6	C	MAB-0
MAB-4088	6	C	MAB-0
MAB-4089	6	CC	MAB-0
MAB-4090	6	CC	MAB-0
MAB-4091	6	C	MAB-0
MAB-4092	6	C	MAB-0
MAB-4093	6	C	MAB-0
MAB-4094	6	C	MAB-0
MAB-4095	6	C	MAB-0
MAB-4098	6	C	MAB-0
MAB-4100	6	C	MAB-0
MAB-4101	6	C	MAB-0
MAB-4103, A	6	C	MAB-0
MAB-4104	6	C	MAB-0
MAB-4105, M	6	C	MAB-0
MAB-4106	6	C	MAB-0
MAB-4108	6	C	MAB-0
MAB-4109	6	CC	MAB-0
MAB-4111	6	C	MAB-0
MAB-4112	6	C	MAB-0
MAB-4114	6	C	MAB-0
MAB-4115	6	C	MAB-0
MAB-4116	12	C	MAB-1
MAB-4117	12	CC	MAB-1
MAB-4118, A	6	C	MAB-0
MAB-4119	6	C	MAB-0
MAB-4120	6	C	MAB-0
MAB-4123	6	C	MAB-0
MAD-4106, A	6	C	MAD-0
MAJ-4010	6	CC	MAJ-0
MAJ-4011	6	C	MAJ-0
MAJ-4016	6	C	MAJ-0
MAJ-4018	6	C	MAJ-0
MAJ-4021	6	C	MAJ-0
MAJ-4024	6	C	MAJ-0
MAJ-4028	6	C	MAJ-0
MAJ-4031	6	C	MAJ-0
MAJ-4033	6	C	MAJ-0
MAJ-4034	6	C	MAJ-0
MAJ-4038	6	C	MAJ-0
MAJ-4039	6	C	MAJ-0
MAJ-4040	6	C	MAJ-0
MAJ-4041	6	C	MAJ-0
MAJ-4042	6	C	MAJ-0
MAJ-4044	6	C	MAJ-0
MAJ-4045	6	C	MAJ-0
MAJ-4046	6	C	MAJ-0
MAJ-4047	6	C	MAJ-0
MAJ-4048	6	CC	MAJ-0
MAJ-4049	6	CC	MAJ-0
MAJ-4050	6	C	MAJ-0
MAJ-4054	6	C	MAJ-0
MAJ-4055	6	CC	MAJ-0
MAJ-4056	6	C	MAJ-0
MAJ-4057	6	C	MAJ-0
MAJ-4058	6	CC	MAJ-0
MAJ-4061	6	C	MAJ-0
MAJ-4062	6	C	MAJ-0
MAJ-4063	6	C	MAJ-0
MAJ-4064	6	C	MAJ-0
MAK-4001	6	C	MAK-0
MAK-4004	6	CC	MAK-0
MAK-4005	6	C	MAK-0
MAK-4006	6	C	MAK-0
MAK-4007	6	C	MAK-0
MAK-4008	6	CC	MAK-0
MAK-4009	6	CC	MAK-0
MAK-4011	6	C	MAK-0
MAK-4012	6	CC	MAK-0
MAK-4013	6	CC	MAK-0
MAK-4014	6	C	MAK-0
MAK-4017	6	C	MAK-0
MAK-4020	6	CC	MAK-0
MAK-4021	6	C	MAK-0
MAK-4022	6	CC	MAK-0
MAK-4023	6	C	MAK-0
MAK-4026	6	C	MAK-0
MAK-4027	6	C	MAK-0
MAK-4028	6	CC	MAK-0
MAK-4029	6	CC	MAK-0
MAK-4030	6	C	MAK-0
MAK-4031	6	CC	MAK-0
MAO-4003, B	6	C	MAO-0
MAS-4001	12	C	MAS-0
MAS-4002	12	CC	MAS-0
MAS-4003	12	C	MAS-0
MAS-4004	12	C	MAS-0
MAS-4005	12	C	MAS-0
MAS-4006	12	CC	MAS-0
MAS-4007	12	CC	MAS-0
MAS-4008	12	C	MAS-0
MAS-4009	12	C	MAS-0
MAS-4010	12	C	MAS-0
MAS-4011	12	C	MAS-0
MAS-4012	12	CC	MAS-0
MAS-4015	12	C	MAS-0
MAS-4016	12	C	MAS-0
MAS-4017	12	C	MAS-0
MAS-4018	12	CC	MAS-0
MAS-4019	12	C	MAS-0
MAS-4102, A	12	C	MAS-1
MAS-4103	12	C	MAS-1
MAS-4104	12	C	MAS-1
MAS-4105	12	C	MAS-1
MAS-4106	12	C	MAS-1
MAU-4005	12	C	MAU-0
MAU-4006	12	C	MAU-0
MAU-4007	12	C	MAU-0
MAU-4008	12	CC	MAU-0
MAU-4010	12	CC	MAU-0
MAU-4011, A	12	C	MAU-1
MAU-4013	12	C	MAU-0
MAU-4016	12	C	MAU-0
MAU-4019	12	CC	MAU-0
MAU-4022	12	C	MAU-0
MAU-4025	12	C	MAU-0
MAU-4033	12	CC	MAU-0
MAU-4036	12	CC	MAU-0
MAU-4037	12	CC	MAU-0
MAU-4040	12	C	MAU-1
MAU-4041	12	C	MAU-0
MAW-4001	6	C	MAW-1
MAW-4002 (2)	6	C	MAW-0
MAW-4003 (2)	6	C	MAW-0
MAW-4004 (2)	6	C	MAW-0
MAW-4005 (2)	6	C	MAW-0
MAW-4006	6	C	MAW-1
MAW-4007, A, M	6	CC	MAW-1
MAW-4008, A, M	6	C	MAW-1
MAW-4009 (2)	6	C	MAW-0
MAW-4010 (2)	6	C	MAW-0
MAW-4011, A (2)	6	C	MAW-0
MAW-4013, A, B(2)	6	C	MAW-0
MAW-4015	6	C	MAW-1
MAW-4016 (2)	6	C	MAW-0
MAW-4018	6	C	MAW-1
MAW-4019, A (2)	6	C	MAW-0
MAW-4020, A	6	C	MAW-1
MAW-4021	6	C	MAW-1
MAW-4022, A (2)	6	C	MAW-0
MAW-4023, A (2)	6	C	MAW-0
MAW-4024 (3)	6	C	MAW-2
MAW-4025 (2)	6	C	MAW-0
MAW-4026 (2)	6	C	MAW-0
MAW-4027 (3)	6	C	MAW-2
MAW-4028	6	C	MAW-1
MAW-4029 (2)	6	C	MAW-0
MAW-4030	6	CC	MAW-1
MAW-4031	6	CC	MAW-1
MAW-4032 (2)	6	C	MAW-0
MAW-4034	6	C	MAW-1
MAW-4035 M (4)	6	C	MAW-2
MAW-4038	6	C	MAW-1
MAW-4039, M	6	C	MAW-1
MAW-4040	6	C	MAW-1
MAW-4041 (4)	6	C	MAW-2
MAW-4042	6	C	MAW-1
MAW-4043 (4)	6	C	MAW-2
MAW-4044 (2)	6	C	MAW-0
MAW-4045 M (4)	6	C	MAW-3
MAW-4046 M (4)	6	CC	MAW-3
MAW-4047 (2)	6	C	MAW-0
MAW-4048	6	CC	MAW-1

C—Clockwise rotation at the drive end. **CC—Counterclockwise rotation at the drive end.**
Test numbers refer to the tests which follow this listing.

STARTING MOTOR SPECIFICATIONS

Starting Motor	Rated Volts	Rotation Drive End	Test No.
MAW-4049	6	CC	MAW-1
MAW-4050	6	CC	MAW-1
MAW-4051	6	C	MAW-1
MAW-4052 (2)	6	C	MAW-0
MAW-4053	6	C	MAW-1
MAW-4054 (4)	6	C	MAW-1
MAW-4055	6	C	MAW-0
MAW-4056 M	6	C	MAW-1
MAX-4003, A (2)	6	C	MAX-0
MAX-4006	6	C	MAX-1
MAX-4007 (2)	6	C	MAX-0
MAX-4008 (5)	6	C	MAX-0
MAX-4009 (6) (8)	6	C	MAX-4
MAX-4010	6	C	MAX-6
MAX-4011	6	C	MAX-6
MAX-4014	6	C	MAX-1
MAX-4015 (2)	6	C	MAX-0
MAX-4016, A (2)	6	C	MAX-0
MAX-4018	6	C	MAX-1
MAX-4019	6	C	MAX-1
MAX-4020, A (2)	6	C	MAX-0
MAX-4022	6	C	MAX-6
MAX-4023, M	6	C	MAX-6
MAX-4025	6	CC	MAX-6
MAX-4026, M	6	CC	MAX-6
MAX-4028 (7)	6	C	MAX-0
MAX-4031, A, B (2)	6	C	MAX-0
MAX-4032	6	C	MAX-1
MAX-4033	6	C	MAX-1
MAX-4034 (2) (8)	6	C	MAX-4
MAX-4035 (2) (8)	6	C	MAX-4
MAX-4037 (9)	6	C	MAX-0
MAX-4038 (2)	6	C	MAX-0
MAX-4039 (2)	6	C	MAX-0
MAX-4040 (2)	6	C	MAX-0
MAX-4041 (10) (8)	6	C	MAX-4
MAX-4044 (7)	6	C	MAX-0
MAX-4045, A (2)	6	C	MAX-0
MAX-4046	6	C	MAX-1
MAX-4048, A (4)	6	C	MAX-2
MAX-4050 (2)	6	C	MAX-0
MAX-4051 (7)	6	C	MAX-0
MAX-4052 (10) (8)	6	C	MAX-4
MAX-4053 (2)	6	C	MAX-0
MAX-4054 (2)	6	C	MAX-0
MAX-4057	6	C	MAX-6
MAX-4058 (4)	6	C	MAX-2
MAX-4059	6	C	MAX-5
MAX-4060 (2)	6	C	MAX-0
MAX-4061 (2)	6	CC	MAX-0
MAX-4062 (2)	6	C	MAX-0
MAX-4063	6	C	MAX-1
MAX-4064	6	C	MAX-1
MAX-4065	6	C	MAX-1
MAX-4066	6	C	MAX-1
MAX-4067 (11)	6	C	MAX-2
MAX-4068 (2)	6	C	MAX-0
MAX-4069 M (4)	6	CC	MAX-3
MAX-4070 M (4)	6	C	MAX-3
MAX-4072	6	C	MAX-1
MAX-4073 (12)	6	C	MAX-2
MAX-4074	6	C	MAX-1
MAX-4075 (13)	12	C	MAX-7
MAX-4076 (2)	6	C	MAX-0
MAX-4077 (15) (14)	6	C	MAX-5

Starting Motor	Rated Volts	Rotation Drive End	Test No.
MAX-4078	6	C	MAX-1
MAX-4079 (2)	6	C	MAX-0
MAX-4080	6	C	MAX-1
MAX-4081	6	CC	MAX-1
MAX-4082 (12)	6	CC	MAX-2
MAX-4083 (13)	6	C	MAX-2
MAX-4084 (13)	12	C	MAX-7
MAX-4085 (2)	6	C	MAX-0
MAX-4086 (2)	6	C	MAX-0
MAX-4087 (4)	6	C	MAX-2
MAX-4088	6	C	MAX-1
MAX-4089 (20)	12	C	MAX-7
MAX-4090 (26)	6	C	MAX-0
MAX-4091	6	C	MAX-1
MAY-4001 (2)	12	C	MAY-0
MAY-4002, A (2)	12	C	MAY-0
MAY-4009, A (2)	12	C	MAY-0
MAY-4010, A (2)	12	C	MAY-0
MAY-4013	12	C	MAY-1
MAY-4014, A (2)	12	C	MAY-0
MAY-4016 (2)	12	C	MAY-0
MAY-4017	12	C	MAY-1
MAY-4018	12	C	MAY-1
MAY-4019	12	C	MAY-1
MAY-4020 (2)	12	C	MAY-0
MAY-4109, A, B (2)	12	C	MAY-0
MAY-4110 A (2)	12	C	MAY-0
MAY-4114, A, B (2)	12	C	MAY-0
MAY-4116 (9)	12	C	MAY-0
MAY-4119	12	C	MAY-1
MAY-4123	12	C	MAY-1
MAY-4124	12	C	MAY-1
MAY-4125 (10) (8)	12	C	MAY-4
MAY-4126	12	C	MAY-1
MAY-4130, M	12	CC	MAY-1
MAY-4131, M	12	C	MAY-1
MAY-4132 (2)	12	C	MAY-0
MAY-4133 (2)	12	C	MAY-0
MAY-4134, M	12	C	MAY-5
MAY-4135, M	12	CC	MAY-5
MAY-4137	12	C	MAY-1
MAY-4138	12	C	MAY-1
MAY-4139	12	C	MAY-5
MAY-4140	12	C	MAY-1
MAY-4141 (7)	12	C	MAY-0
MAY-4144 U (2)	12	C	MAY-0
MAY-4145 (4)	12	C	MAY-2
MAY-4147 (2)	12	C	MAY-0
MAY-4148	12	C	MAY-1
MAY-4149 M (4)	12	CC	MAY-3
MAY-4150 M (4)	12	C	MAY-3
MAY-4151 (2)	12	C	MAY-0
MBA-4001	6	C	MBA-0
MBA-4002	6	C	MBA-0
MBD-4001 (16)	24	C	MBD-0
MBD-4002 (16)	24	C	MBD-0
MBD-4003 (9)	24	C	MBD-0
MBD-4004	24	C	MBD-1
MBD-4005 (9)	24	C	MBD-0
MBD-4006 (9)	24	CC	MBD-0
MBD-4007, A, B	24	C	MBD-2
MBD-4008, A, M	24	C	MBD-1
MBD-4009	24	C	MBD-1
MBD-4010, A	24	C	MBD-2
MBD-4011	24	C	MBD-1

Starting Motor	Rated Volts	Rotation Drive End	Test No.
MBD-4013	24	C	MBD-1
MBD-4015, M	24	C	MBD-3
MBD-4016	24	C	MBD-1
MBD-4017	24	C	MBD-1
MBD-4018	24	C	MBD-1
MBD-4019 M	24	C	MBD-1
MBD-4022	24	C	MBD-1
MBD-4023	24	C	MBD-1
MBD-4024	24	C	MBD-1
MBD-4025	24	C	MBD-1
MBD-4026	24	C	MBD-1
MBD-4027	24	C	MBD-1
MBD-4028, A	24	CC	MBD-1
MBD-4029 M	24	C	MBD-1
MBD-4030, M	24	C	MBD-1
MBD-4031	24	C	MBD-1
MBD-4032	24	C	MBD-1
MBD-4033	24	C	MBD-1
MBE-4001	12	C	MBE-0
MBE-4003, A	12	CC	MBE-0
MBG-4004	12	C	MBG-0
MBG-4006	12	C	MBG-0
MBG-4008	12	C	MBG-0
MBG-4009	12	C	MBG-0
MBG-4011	12	C	MBG-0
MBG-4015	12	C	MBG-0
MBG-4017	12	CC	MBG-0
MBG-4018	12	CC	MBG-0
MBJ-4101	12	C	MBJ-0
MBJ-4103	12	C	MBJ-0
MBJ-4104	12	C	MBJ-0
MBJ-4105	12	C	MBJ-0
MBJ-4106	12	C	MBJ-0
MBJ-4107	12	CC	MBJ-0
MBJ-4108	12	CC	MBJ-0
MBJ-4109	12	C	MBJ-0
MBJ-4110	12	C	MBJ-0
MBJ-4111	12	C	MBJ-0
MBJ-4112	12	C	MBJ-1
MBJ-4114	12	C	MBJ-0
MBJ-4115 (2)	12	C	MBJ-2
MBP-4005	24	C	MBP-0
MBR-4001	12	C	MBR-0
MBR-4002	12	C	MBR-0
MBR-4003	12	C	MBR-0
MBR-4004	12	C	MBR-0
MBR-4006	12	C	MBR-0
MBR-4007	12	C	MBR-0
MBR-4008	12	C	MBR-1
MBR-4010	12	C	MBR-0
MBR-4012	12	C	MBR-0
MBR-4013	12	C	MBR-0
MBR-4014	12	C	MBR-0
MBR-4015	12	C	MBR-0
MBR-4016	12	C	MBR-0
MBR-4017 M	12	C	MBR-0
MBR-4018 M	12	CC	MBR-0
MBR-4019	12	C	MBR-0
MBR-4020	12	C	MBR-0
MBR-4021	12	C	MBR-0
MBR-4022	12	CC	MBR-0
MBR-4023	12	C	MBR-0
MBY-4001	24	C	MBY-0
MBY-4002	24	C	MBY-0
MBY-4003	24	C	MBY-0

C—Clockwise rotation at the drive end. CC—Counterclockwise rotation at the drive end.
Test numbers refer to the tests which follow this listing.

Starting Motor	Rated Volts	Rotation Drive End	Test No.
MBY-4004	24	C	MBY-0
MCC-4001 M	24	C	MCC-0
MCH-4001 (17)	6	C	MCH-1
MCH-6001 M (3)	6	C	MCH-1
MCH-6002 M (3)	6	CC	MCH-1
MCH-6003 (3)	6	C	MCH-1
MCH-6004 (18)	6	C	MCH-1
MCH-6101 (4)	6	C	MCH-1
MCH-6102 (2)	6	C	MCH-0
MCH-6103 (2)	6	C	MCH-0
MCH-6104 (4)	6	C	MCH-1
MCH-6105 (26)	6	C	MCH-0
MCJ-4001 (19)	12	CC	MCJ-0
MCJ-4002 (19)	12	CC	MCJ-0
MCJ-6001 M (3)	12	C	MCJ-0
MCJ-6002 M (3)	12	CC	MCJ-0
MCK-4001	12	C	MCK-0
MCK-4002	12	C	MCK-0
MCL-6001AM,M (3)	6	C	MCL-1
MCL-6002AM,M (3)	6	CC	MCL-1
MCL-6003 (3)	6	C	MCL-1
MCL-6004 (13)	6	C	MCL-1
MCL-6005 (13)	6	CC	MCL-1
MCL-6006 (20)	6	C	MCL-1
MCL-6007 (4)	6	C	MCL-1
MCL-6008 (21)	6	C	MCL-1
MCL-6009 (13)	6	C	MCL-1
MCL-6010 M (3)	6	C	MCL-1
MCL-6011 M	6	CC	MCL-1
MCL-6012 (13)	6	C	MCL-1
MCL-6013 (18)	6	C	MCL-1
MCL-6101 (2)	6	C	MCL-0
MCL-6102 (2)	6	C	MCL-0
MCL-6103 (2)	6	C	MCL-0
MCL-6104	6	CC	MCL-2
MCL-6105, M	6	C	MCL-2
MCL-6106	6	CC	MCL-2
MCL-6107 (26)	6	C	MCL-0
MCL-6108 (26)	6	C	MCL-0
MCL-6109 (26)	6	C	MCL-0
MCO-4001	12	C	MCO-0
MCO-4002	12	C	MCO-0
MCT-6101 (26)	12	C	MCT-0
ML-4115	6	C	ML-0
ML-4122	6	C	ML-0
ML-4130	6	C	ML-0
ML-4140	12	CC	ML-2
ML-4144	6	C	ML-0
ML-4145	12	C	ML-2
ML-4151	6	C	ML-0
ML-4154	6	C	ML-0
ML-4156	6	C	ML-0
ML-4157	6	CC	ML-0
ML-4162	6	C	ML-0
ML-4163	6	C	ML-0
ML-4166	6	C	ML-0
ML-4170	6	C	ML-0
ML-4173	12	C	ML-2
ML-4175	6	C	ML-0
ML-4176, A	6	C	ML-0
ML-4177	12	C	ML-2
ML-4178	12	C	ML-2
ML-4179	6	C	ML-0
ML-4180	6	C	ML-0
ML-4181	6	CC	ML-0
ML-4185	12	C	ML-2
ML-4186	6	C	ML-0
ML-4187	6	C	ML-0
ML-4189	6	C	ML-0
ML-4191	6	C	ML-0
ML-4192	6	C	ML-0
ML-4193	12	C	ML-2
ML-4196	12	C	ML-2
ML-4197	6	CC	ML-0
ML-4198	6	C	ML-0
ML-4199	6	C	ML-0
ML-4200	6	C	ML-0
ML-4201	12	C	ML-2
ML-4202	6	C	ML-0
ML-4203	12	C	ML-2
ML-4205	6	C	ML-0
ML-4207	6	C	ML-0
ML-4208	12	C	ML-2
ML-4209, A	12	C	ML-2
ML-4210	12	C	ML-2
ML-4211	6	C	ML-0
ML-4212	6	C	ML-0
ML-4213	12	C	ML-2
ML-4214	6	C	ML-0
ML-4215	6	C	ML-0
ML-4216	6	C	ML-0
ML-4218	12	C	ML-2
ML-4219	12	CC	ML-2
ML-4220	6	C	ML-0
ML-4221	6	C	ML-0
ML-4301	12	C	ML-3
ML-4302 M	12	C	ML-3
ML-4303	6	C	ML-1
ML-4304 (13)	12	C	ML-4
ML-4305	6	C	ML-1
ML-4306 (13)	12	C	ML-4
ML-4307	12	C	ML-3
ML-4308	12	C	ML-3
ML-4309	6	C	ML-1
ML-4310, A	6	C	ML-1
ML-4311 (13)	12	C	ML-4
ML-4312	6	C	ML-1
ML-4313	6	C	ML-1
ML-4314	12	C	ML-3
ML-4315 M (13)	12	C	ML-4
ML-4316	12	C	ML-3
ML-4318	6	C	ML-1
ML-4319	12	C	ML-3
ML-4320 M	12	C	ML-3
ML-4321 M	6	C	ML-1
ML-4322	12	C	ML-3
ML-4323	12	C	ML-3
ML-4324	6	C	ML-1
ML-4325	6	CC	ML-1
ML-4326 (13)	12	C	ML-4
ML-4327	12	C	ML-3
ML-4329	6	C	ML-1
ML-4330	6	C	ML-1
ML-4331	6	C	ML-1
ML-4332	6	C	ML-1
ML-4334	6	C	ML-1
MR-4104, M	6	C	MR-0
MR-4108	12	C	MR-1
MR-4111	12	C	MR-1
MR-4112	6	C	MR-0
MR-4113, A	6	C	MR-0
MR-4114	12	C	MR-1
MR-4115, A	6	C	MR-0
MR-4116	12	C	MR-1
MR-4117	12	CC	MR-1
MR-4118	12	C	MR-1
MR-4119, A	12	C	MR-1
MR-4120	12	C	MR-1
MR-4121	12	CC	MR-1
MR-4122	12	C	MR-1
MUB-4007, A	6	C	MUB-0
MZ-4008	6	C	MZ-1
MZ-4019	6	C	MZ-1
MZ-4020	6	C	MZ-1
MZ-4022	6	CC	MZ-1
MZ-4025	6	C	MZ-1
MZ-4027, A	6	C	MZ-1
MZ-4028	6	C	MZ-1
MZ-4031, A	6	C	MZ-1
MZ-4033	6	C	MZ-1
MZ-4035	6	C	MZ-1
MZ-4036	6	C	MZ-1
MZ-4037	6	C	MZ-1
MZ-4040	6	C	MZ-1
MZ-4041	6	CC	MZ-1
MZ-4042	6	CC	MZ-1
MZ-4045, M	6	C	MZ-1
MZ-4046	6	C	MZ-1
MZ-4047	6	C	MZ-1
MZ-4048	12	C	MZ-3
MZ-4049	6	C	MZ-1
MZ-4050	6	C	MZ-1
MZ-4051	6	C	MZ-1
MZ-4055	6	CC	MZ-1
MZ-4056 (2)	6	C	MZ-0
MZ-4057	6	C	MZ-1
MZ-4058	6	CC	MZ-1
MZ-4059, A (2)	6	C	MZ-0
MZ-4060	12	C	MZ-3
MZ-4062, A (2)	6	C	MZ-0
MZ-4063	6	C	MZ-1
MZ-4064	6	C	MZ-1
MZ-4065	6	C	MZ-1
MZ-4066	6	C	MZ-1
MZ-4067	6	C	MZ-1
MZ-4068	6	C	MZ-1
MZ-4069	6	CC	MZ-1
MZ-4070	12	C	MZ-3
MZ-4071	6	C	MZ-1
MZ-4072	6	C	MZ-1
MZ-4073	6	C	MZ-1
MZ-4074 (22)	6	C	MZ-2
MZ-4076	6	C	MZ-1
MZ-4077	6	CC	MZ-1
MZ-4078	6	C	MZ-1
MZ-4079, A	6	C	MZ-1
MZ-4080	6	CC	MZ-1
MZ-4082	6	C	MZ-1
MZ-4085	6	C	MZ-1
MZ-4086	6	CC	MZ-1
MZ-4087	6	C	MZ-1
MZ-4089, A (2)	6	C	MZ-0
MZ-4090 (22)	6	C	MZ-2
MZ-4091	6	C	MZ-1
MZ-4092	6	C	MZ-1

C—Clockwise rotation at the drive end. CC—Counterclockwise rotation at the drive end.
Test numbers refer to the tests which follow this listing.

Starting Motor	Rated Volts	Rotation Drive End	Test No.
MZ-4093	6	C	MZ-1
MZ-4094	6	C	MZ-1
MZ-4095, M	6	C	MZ-1
MZ-4096	6	C	MZ-1
MZ-4098	6	C	MZ-1
MZ-4099	6	C	MZ-1
MZ-4100	6	C	MZ-1
MZ-4101 (23)	6	CC	MZ-0
MZ-4102	6	C	MZ-1
MZ-4103	6	C	MZ-1
MZ-4104	6	CC	MZ-1
MZ-4105 (2)	6	C	MZ-0
MZ-4106	6	C	MZ-1
MZ-4107	6	C	MZ-1
MZ-4108	6	C	MZ-1
MZ-4109	6	C	MZ-1
MZ-4111	6	C	MZ-1
MZ-4112	6	C	MZ-1
MZ-4113	6	C	MZ-1
MZ-4114, M	6	C	MZ-1
MZ-4115 (2)	6	C	MZ-0
MZ-4118, M	6	CC	MZ-1
MZ-4120, M	6	C	MZ-1
MZ-4121	6	C	MZ-1
MZ-4123	6	C	MZ-1
MZ-4124	12	C	MZ-4
MZ-4127	6	C	MZ-1
MZ-4128	6	C	MZ-1
MZ-4129	6	C	MZ-1
MZ-4130, A	6	C	MZ-1
MZ-4131	6	C	MZ-1
MZ-4132	6	C	MZ-1
MZ-4133 (4)	6	C	MZ-2
MZ-4135	6	C	MZ-1
MZ-4136 (24)	6	C	MZ-2
MZ-4137 (25)	6	C	MZ-0
MZ-4138	6	C	MZ-1
MZ-4139 (4)	6	C	MZ-2
MZ-4140	6	C	MZ-1
MZ-4142	6	CC	MZ-1
MZ-4143 (2)	6	C	MZ-0
MZ-4144, M (4)	6	C	MZ-2
MZ-4145	6	CC	MZ-1
MZ-4146, A	6	CC	MZ-1
MZ-4147	6	C	MZ-1
MZ-4148 (2)	6	C	MZ-0
MZ-4149 (4)	6	C	MZ-2
MZ-4150	6	C	MZ-1
MZ-4151 (24)	6	C	MZ-2
MZ-4152 (4)	6	C	MZ-2
MZ-4153	6	C	MZ-1
MZ-4154 (2)	6	C	MZ-0
MZ-4155	6	CC	MZ-1
MZ-4156 (4)	6	C	MZ-2
MZ-4157 (24)	6	C	MZ-2
MZ-4158	6	C	MZ-1
MZ-4159 (20)	6	C	MZ-1
MZ-4160	6	C	MZ-1

(1) Pinion position—1.638 to 1.840 inches from face of mounting flange to edge of pinion.
(2) Pinion position—1.188 to 1.359 inches from face of mounting flange to edge of pinion.
(3) Pinion position— .816 to .937 inches from face of mounting flange to edge of pinion.
(4) Pinion position—1.220 to 1.342 inches from face of mounting flange to edge of pinion.
(5) Pinion position—1.219 to 1.391 inches from face of mounting flange to edge of pinion.
(6) Pinion position—2.188 to 2.359 inches from center of locating hole to edge of pinion.
(7) Pinion position— .438 to .609 inches from face of mounting flange to edge of pinion.
(8) .005 to .050 inches clutch shaft end play.
(9) Pinion position— .875 to 1.047 inches from face of mounting flange to edge of pinion.
(10) Pinion position— .781 to .953 inches from face of mounting flange to edge of pinion.
(11) Pinion position— .691 to .813 inches from face of mounting flange to edge of pinion.
(12) Pinion position— .706 to .828 inches from face of mounting flange to edge of pinion.
(13) Pinion position—1.722 to 1.841 inches from face of mounting flange to edge of pinion.
(14) .005 to .010 inches Bendix shaft end play.
(15) Pinion position— .769 to .875 inches from face of mounting flange to edge of pinion.
(16) Pinion position— .797 to .828 inches from face of mounting flange to edge of pinion.
(17) Pinion position— .434 to .557 inches from face of mounting flange to edge of pinion.
(18) Pinion position— .910 to 1.032 inches from face of mounting flange to edge of pinion.
(19) Pinion position—2.253 to 2.375 inches from center of locating hole to edge of pinion.
(20) Pinion position—1.949 to 2.071 inches from face of mounting flange to edge of pinion.
(21) Pinion position—1.531 to 1.653 inches from face of mounting flange to edge of pinion.
(22) Pinion position—1.424 to 1.546 inches from face of mounting flange to edge of pinion.
(23) Pinion position—3.490 to 3.510 inches from center of locating hole to edge of pinion.
(24) Pinion position—1.052 to 1.174 inches from face of mounting flange to edge of pinion.
(25) Pinion position— .625 to .797 inches from face of mounting flange to edge of pinion.
(26) Pinion position—1.317 to 1.467 inches from face of mounting flange to edge of pinion.

C—Clockwise rotation at the drive end.
CC—Counterclockwise rotation at the drive end

Test numbers refer to the tests which follow this listing.

STARTING MOTOR TESTS

Test No.	Rated Volts	Brush Spring Tension (Ounces)	Armature End Play (Inches)	Transmission	NO LOAD TEST Volts	NO LOAD TEST Max. Amperes	NO LOAD TEST Min. R.P.M.	STALL TORQUE TEST Volts	STALL TORQUE TEST Max. Amperes	STALL TORQUE TEST Min. Lbs. Ft.
DI-0	6	56-60	.005-.062	Bendix	6.0	60	4500	3.6	730	29.2
DN-0	6	56-60	.005-.062	Bendix	6.0	50	3000	3.6	810	39.0
MAB-0	6	42-53	.005-.062	Bendix	5.0	60	3600	2.0	390	9.2
MAB-1	12	42-53	.005-.062	Bendix	5.0	60	3600	4.0	775	22.5
MAD-0	6	42-53	.005-.062	Bendix	5.0	60	3400	2.0	325	7.0
MAJ-0	6	42-53	.005-.062	Bendix	5.0	64	3900	2.0	350	6.5
MAK-0	6	38-61	.005-.062	Bendix	5.0	70	4700	2.0	250	2.5
MAO-0	6	24-32	.005-.062	Bendix	5.0	42	2600	2.0	450	19.4

Test No.	Rated Volts	Brush Spring Tension (Ounces)	Armature End Play (Inches)	Trans-mission	NO LOAD TEST			STALL TORQUE TEST		
					Volts	Max. Amperes	Min. R.P.M.	Volts	Max. Amperes	Min. Lbs. Ft.
MAS-0	12	12-16	.005-.062	Bendix	10.0	40	3900	4.0	340	13.2
MAS-1	12	42-53	.005-.062	Bendix	10.0	40	3900	4.0	340	13.2
MAU-0	12	42-53	.005-.062	Bendix	10.0	65	4500	4.0	350	11.1
MAU-1	12	42-53	.005-.062	Bendix	10.0	60	2300	4.0	350	21.0
MAW-0	6	42-53	.005-.030	Clutch	5.0	65	4300	2.0	335	6.0
MAW-1	6	42-53	.005-.062	Bendix	5.0	65	4300	2.0	335	6.0
MAW-2	6	42-53	.005 min.	Bendix	5.0	65	4300	2.0	335	6.0
MAW-3	6	42-53	.005 min	Bendix	5.0	110	3600	2.0	335	6.0
MAX-0	6	42-53	.005-.030	Clutch	5.0	65	4900	2.0	410	8.0
MAX-1	6	42-53	.005-.062	Bendix	5.0	65	4900	2.0	410	8.0
MAX-2	6	42-53	.005 min.	Bendix	5.0	65	4900	2.0	410	8.0
MAX-3	6	42-53	.005 min.	Bendix	5.0	110	3900	2.0	410	8.0
MAX-4	6	42-53	.005-.075	Clutch	5.0	74	2360	2.0	410	13.0
MAX-5	6	42-53	.005-.062	Bendix	5.0	74	2360	2.0	410	13.0
MAX-6	6	42-53	.005-.062	Bendix	5.0	65	3120	2.0	410	11.0
MAX-7	12	42-53	.005 min.	Bendix	10.0	100	6400	4.0	880	25.0
MAY-0	12	42-53	.005-.030	Clutch	10.0	35	4800	4.0	175	6.7
MAY-1	12	42-53	.005-.062	Bendix	10.0	35	4800	4.0	175	6.7
MAY-2	12	42-53	.005 min.	Bendix	10.0	35	4800	4.0	175	6.7
MAY-3	12	42-53	.005 min.	Bendix	10.0	85	2000	4.0	175	6.7
MAY-4	12	42-53	.005-.075	Clutch	10.0	42	2300	4.0	170	12.5
MAY-5	12	42-53	.005-.062	Bendix	10.0	45	2900	4.0	185	8.0
MBA-0	6	42-53	.005-.062	Bendix	5.0	60	4300	2.0	315	5.7
MBD-0	24	34-43	.005-.030	Clutch	20.0	65	5300	6.0	590	35.0
MBD-1	24	34-43	.005-.030	Bendix	20.0	65	5300	6.0	590	35.0
MBD-2	24	34-43	.005-.030	Bendix	20.0	75	1490	6.0	590	105.0
MBD-3	24	34-43	.005-.030	Bendix	20.0	75	3500	6.0	590	50.0
MBE-0	12	38-61	.005-.062	Bendix	10.0		5800	4.0	190	2.2
MBG-0	12	42-53	.005-.062	Bendix	10.0	50	6900	4.0	235	5.2
MBJ-0	12	42-53	.005-.062	Bendix	10.0	65	6000	4.0	400	10.0
MBJ-1	12	42-53	.005-.062	Bendix	10.0	85	2600	4.0	400	17.0
MBJ-2	12	42-53	.005-.030	Clutch	10.0	65	6000	4.0	400	10.0
MBP-0	24	42-53	.005-.062	Bendix	10.0	16	2600	6.0	70	3.3
MBR-0	12	34-43	.005-.030	Bendix	10.0	100	4000	4.0	1100	40.0
MBR-1	12	34-43	.005-.030	Bendix	10.0	115	2900	4.0	1100	50.0
MBY-0	24	42-53	.005-.062	Bendix	20.0	20	4200	8.0	125	9.0
MCC-0	24	34-43	.005-.030	Bendix	20.0	70	5400	6.0	470	20.0
MCH-0	6	42-53	.005-.030	Clutch	5.0	65	4300	2.0	335	6.0
MCH-1	6	42-53	.005 min.	Bendix	5.0	65	4300	2.0	335	6.0
MCJ-0	12	42-53	.005 min.	Bendix	10.0	35	4800	4.0	175	6.7
MCK-0	12	34-43	.005-.030	Bendix	10.0	130	4700	4.0	1300	33.0
MCL-0	6	42-53	.005-.030	Clutch	5.0	65	4900	2.0	410	8.0
MCL-1	6	42-53	.005 min.	Bendix	5.0	65	4900	2.0	410	8.0
MCL-2	6	42-53	.005-.062	Bendix	5.0	65	4900	2.0	410	8.0
MCO-0	12	34-43	.005-.030	Bendix	10.0	100	4700	3.0	980	36.0
MCT-0	12	42-53	.005-.030	Clutch						
ML-0	6	12-16	.005-.062	Bendix	5.0	65	2250	2.0	370	10.3
ML-1	6	42-53	.005-.062	Bendix	5.0	65	2250	2.0	370	10.3
ML-2	12	12-16	.005-.062	Bendix	10.0	80	3900	4.0	750	26.0
ML-3	12	42-53	.005-.062	Bendix	10.0	80	3900	4.0	750	26.0
ML-4	12	42-53	.005 min.	Bendix	10.0	80	3900	4.0	750	26.0
MR-0	6	12-16	.005-.062	Bendix	5.0	50	2700	2.0	350	17.0
MR-1	12	12-16	.005-.062	Bendix	10.0	60	4200	4.0	700	43.0
MUB-0	6	22-28	.005-.062	Bendix	5.0	45	3000	2.0	280	5.5
MZ-0	6	42-53	.005-.030	Clutch	5.0	68	4000	2.0	280	4.4
MZ-1	6	42-53	.005-.062	Bendix	5.0	68	4000	2.0	280	4.4
MZ-2	6	42-53	.005 min.	Bendix	5.0	68	4000	2.0	280	4.4
MZ-3	12	42-53	.005-.062	Bendix	10.0	50	6900	4.0	235	5.2
MZ-4	12	42-53	.005-.062	Bendix	10.0	75	5500	4.0	560	10.0

SOLENOID SWITCH SPECIFICATIONS.

Part Number	Rated Volts	Control Circuit	Coil Draw*		Contacts* Close Volts	Contacts* Open Volts	Pull-in Coil Draw		Hold-in Coil Draw	
			Volts	Amperes			Volts	Amperes	Volts	Amperes
SS-4001, A, B, C	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4002	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4003, A, B, C	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4004	6	No. 10-32 term. to "Bat" term.	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4005	6	No. 10-32 term. to "Bat" term.	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4006, A	6	No. 10-32 term. to "Bat" term.	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4007	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4008	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4009 S	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4010	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4011	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4012	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4013	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4014, A	6	No. 10-32 term. to "Bat" term.	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4015	12	No. 10-32 term. to "Bat" term.	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4016	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4017	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4018	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4020, A, B	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4021	6	No. 10-32 term. to "Bat" term.	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4022	12	No. 10-32 term. to "Bat" term.	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4023	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4024	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4025	6	Two No. 10-32 terminals	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4026	6	Two No. 10-32 terminals	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4027	6	No. 10-32 term. to "Bat" term.	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4028	12	Two No. 10-32 terminals	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4101, A	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4103	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-33.0	6.0	3.0-3.4
SS-4104	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4105	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4106	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4107	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4201, S	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4202, S	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4203, A, S	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4204, A, S	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4205	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4206	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4207, A	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4208	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	27.0-30.0	3.0	7.0-8.0
SS-4209, A	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4210	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4211	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4212	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4213	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4214	12	Two No. 10-32 terminals	12.0	.37-.42	7.0-9.0	3.0-5.0	6.0	20.6-23.0	6.0	3.0-3.4
SS-4301, A, B	12	No. 10-32 terminal to ground	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4302	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4303	12	No. 10-32 terminal to ground	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4304	12	No. 10-32 term. to "Bat" term.	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4305, M	12	No. 10-32 term. to "Bat" term.	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4306	12	No. 10-32 term. to "Bat" term.	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4307	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4308	6	No. 10-32 term. to "Bat" term.	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SS-4309	12	No. 10-32 terminal to ground	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4310	12	No. 10-32 terminal to ground	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4311	12	Two No. 10-32 terminals	12.0	3.7-4.3	5.5-8.0	0.8-2.0	.....	....	.....	....
SS-4401	24	Two No. 10-32 terminals	.....	....	....	....	12.0	16.1-17.2	12.0	2.7-2.9
SS-4501	24	No. 10-32 term. to "Mot" term.	24.0	2.9-3.3	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4502	24	No. 10-32 terminal to ground	24.0	2.9-3.3	6.0-8.5	1.0-2.5	.....	....	.....	....
SS-4503	24	No. 10-32 terminal to ground	24.0	2.9-3.3	9.0-12.5	1.5-3.5	.....	....	.....	....
SS-4504	24	Two No. 10-32 terminals	24.0	2.9-3.3	9.0-12.5	1.5-3.5	.....	....	.....	....
SS-4505	24	Two No. 10-32 terminals	24.0	2.9-3.3	9.0-12.5	1.5-3.5	.....	....	.....	....
SS-4506	24	Two No. 10-32 terminals	24.0	2.9-3.3	9.0-12.5	1.5-3.5	.....	....	.....	....

*Relay test data on clutch shifting types.

Part Number	Rated Volts	Control Circuit	Coil Draw* Volts	Coil Draw* Amperes	Contacts* Close Volts	Contacts* Open Volts	Pull-in Coil Draw Volts	Pull-in Coil Draw Amperes	Hold-in Coil Draw Volts	Hold-in Coil Draw Amperes
SS-4601	24	Two No. 10-32 terminals	.....	....	....	....	12.0	38.7-45.7	12.0	7.0-8.1
SS-4702	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	38.0-42.0	3.0	7.0-8.0
SS-4703	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	38.0-42.0	3.0	7.0-8.0
SS-4704, S	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	38.0-42.0	3.0	7.0-8.0
SS-4705	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	38.0-42.0	3.0	7.0-8.0
SS-4706	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	38.0-42.0	3.0	7.0-8.0
SS-4707	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	38.0-42.0	3.0	7.0-8.0
SS-4708	6	Two No. 10-32 terminals	6.0	0.7-0.8	3.5-4.5	1.5-2.5	3.0	38.0-42.0	3.0	7.0-8.0
SS-4801	24	No. 10-32 terminal to ground	24.0	0.8-0.9	11.5-16.0	2.0-5.0	.....	....	.....	....
SS-4802	24	No. 10-32 terminal to ground	24.0	0.8-0.9	11.5-16.0	2.0-5.0	.....	....	.....	....
SSO-4001 M	24	No. 10-32 terminal to ground	24.0	0.3-0.4	12.0-18.0	3.0-8.5	.....	....	.....	....
SSP-4001 M	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SSR-4001 M	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SST-4001, A	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SST-4002	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SST-4003	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SST-4004	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SST-4005 M	6	No. 10-32 terminal to ground	6.0	2.9-3.3	3.0-4.0	0.5-1.25	.....	....	.....	....
SSU-4001	24	No. 10-32 terminal to ground	24.0	0.8-0.9	11.5-16.0	2.0-5.0	.....	....	.....	....
SSW-4001	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SSW-4002 M	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SSW-4003	12	No. 10-32 terminal to ground	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SSW-4004	12	No. 10-32 term. to "Bat" term.	12.0	1.4-1.6	6.0-8.5	1.0-2.5	.....	....	.....	....
SSX-4001	6	‡	.....	....	....	....	3.0	38.0-42.0	3.0	7.0-8.0
SSX-4101	6	Two No. 10-32 terminals	6.0	....	12.8-18.0	3.0-8.5	3.0	38.0-42.0	3.0	7.0-8.0
WSE-4001, A	24	Two No. 10-32 terminals	24.0	3.1-3.5	10.0 max.	0.5-3.0	.....	....	.....	....
WSE-4002	24	Two No. 10-32 terminals	24.0	3.1-3.5	10.0 max.	0.5-3.0	.....	....	.....	....
WSE-4003	24	Two No. 10-32 terminals	24.0	3.1-3.5	10.0 max.	0.5-3.0	.....	....	.....	....
WSE-4101, A	24	Two No. 10-32 terminals	24.0	3.1-3.5	10.0 max.	0.5-3.0	.....	....	.....	....

*Relay test data on clutch shifting types.

‡ Pull-in coil is connected from the No. 10-32 terminal to the motor terminal and the hold-in coil is connected from the No. 10-32 terminal to ground.

TWO STEP STARTER CONTROL SPECIFICATIONS

Part Number	MBD-3155	MBD-3214	MBD-3240	MBR-3155	MBR-3214
Rated Voltage	24	24	24	12	12
Solenoid Switch	2 used	2 used	2 used	2 used	2 used
Part Number	SS-4504	SS-4504	SS-4503	SS-4310	SS-4310
Current Draw	2.9-3.3A. at 24V.	2.9-3.3A. at 24V.	2.9-3.3A. at 24V.	3.7-4.3A. at 12V.	3.7-4.3A. at 12V.
Closing Volts	9.0-12.5	9.0-12.5	9.0-12.5	5.5-8.0	5.5-8.0
Opening Volts	1.5-3.5	1.5-3.5	1.5-3.5	0.8-2.0	0.8-2.0
Resistance unit (ohms)	.114-.126	.114-.126	.114-.126	0.338-0.374	0.338-0.374
Carbon Resistor (ohms)	57-63	57-63	57-63	13.5-16.5	13.5-16.5
Grounded	No	No	Yes	Yes	Yes
Relay					
Part Number	HRG-4001	HRG-4001	HRG-4001	HRG-4001	HRG-4001
Armature air gap*	.034"-.038"	.034"-.038"	.034"-.038"	.034"-.038"	.034"-.038"
Closing Volts‡	3.0-4.0	3.0-4.0	3.0-4.0	3.4-4.0	3.0-4.0
Opening Volts†	0.4-1.2	0.4-1.2	0.4-1.2	0.4-1.2	0.4-1.2
Time Delay† (seconds)	0.15-0.25	0.15-0.25	0.15-0.25	0.15-0.25	0.15-0.25

* Adjust by bending upper stationary contact bracket.

† Adjust by varying height of lower stationary contact.

‡ Adjust by changing spring tension.